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How to Build Up the Road Construction Industry

Of the 3,000,000 miles of roads in America only 22 per cent receive any real maintenance; and less than 2½ per cent (about 70,000 miles), are first class. So when we pride ourselves on the progress that we have made in road improvement, let us be sobered by such facts.

The plain truth (and it cannot be too often repeated) is that America has barely begun to improve her highways. We point with pride to the $250,000,000 that the gasoline tax yields annually for road construction and maintenance, but it is only $10 per motor car, and when thus viewed it is a very small toll for the use of the highways.

Since road improvement is largely a permanent investment that will serve future generations, it follows that most of the money spent for new construction should be raised by bond issues; and most of the money secured by the gasoline tax should be used to pay interest on the bonds. If it were all used for that purpose, it would pay the interest on more than five billion dollars worth of road bonds. Large as that sum seems, it would build only 200,000 miles of roads at $25,000 a mile.

We must accustom ourselves to the use of much larger figures in speaking of the sums needed for road construction and maintenance. A billion dollars annually for highways is a monthly billing expression, but it is only $40 per motor car per annum. If the average motor car represents an investment of $600, and its life averages five years, then its annual depreciation is $120, exclusive of current maintenance. Hence the annual depreciation charge is about three times the expenditure for road construction. No motorist capable of weighing such economic facts would hesitate to approve a road construction budget two or three fold the present budget. But if he hears only such expressions as "a billion dollars annually for road improvement," he is apt to think that we are improving our roads fast enough. Therefore let him be given statistics that he can better comprehend, and that show the gross inadequacy of our present road building expenditures.

The income of the American people is nearly 100 billion dollars a year. Since practically every family owns a motor car, and finds its greatest single pleasure in its use, does it seem reasonable to spend only one per cent of our income for the improvement of our highways?

Due to rapid improvements in machinery used in manufacturing and farming, every year sees many men thrown out of work, and only by developing new products or by increasing the use of old products can all our people be furnished with jobs. There is no "old product" for which the latent demand is so great as improved highways. Here, then, is a field for employment that for many years can be made to absorb a large part of the labor that is annually rendered unnecessary in other fields by virtue of the rapid improvements in production machinery and methods.

Why the Two-Car Family Will Soon Typify America

A recent motor car survey in Los Angeles discloses that 284,500 families own 391,726 passenger cars. This is almost 1.4 cars per family. Los Angeles was the first large city to average one motor car per family. Now that it has bettered that record by 40 per cent, it serves as an automobile "saturation" gauge that the rest of the nation will soon equal, and which Los Angeles will then surpass.

The steady decline in price and the improvement in quality of cars, coupled with increasing mileage and width of paved roads, forecasts an increasing number of cars per family. Moreover, the "turn-in price" of old cars is relatively so low that the practice of keeping old cars is growing. One of the large manufacturers has been advertising to accelerate the growth of this practice.

The flock of old cars to be seen around high schools indicates that many a parent has turned "the old bus" over to his son or daughter. It has been predicted that most of the old cars will find their way to foreign countries. Our prediction is that for every old car that goes abroad ten will remain at home, in use by other members of the family than paterfamilias.

H. P. Gillette

New Officials of American Road Builders Association

Col. R. Keith Compton, Director of the Richmond, Va., Department of Public Works, became president of the American Road Builders Association at the annual banquet of the organization held in Washington May 11. Col. Compton was elected last January.

Col. Compton served for many years as head of the Public Works Department of the City of Baltimore. He has been prominent in consulting work during the past ten years and served on a number of important comittees organized by the Department of Commerce.

Col. Compton served during the war as a lieutenant colonel in the Engineering corps. He received his honorable discharge following that conflict and entered the reserve, where he still holds his commission.

The new president is extremely well known among the road officials of the United States, having served as a member of the Board of Directors of the American Road Builders Association for many years. He was Chairman of Pan-American Day during the 1927 Road Show and Convention held in Chicago, and in that capacity did much to increase the interest of these countries in the activities of the association.

Col. Compton will serve as president of the association to succeed Charles M. Babcock, Chairman of the Minnesota State Highway Commission, who retires to become a past president and member of the Board. His term will expire in May, 1929, his successor to be elected next January.

J. H. Cranford, a former president and director of the American Road Builders Association, was elected by the Board to fill the vacancy made by Col. Compton.

D. B. Dimick, president of the American Casting Co., Birmingham, was installed as vice-president.

S. M. Williams, Associated General Contractors of America, Washington, took office as a director of the American Road Builders' Association during the May meeting. Mr. Williams has been chairman of the Constructor's program committee of the annual convention for several years.

W. R. Neel, Chief Highway Engineer of the Georgia State Highway Department, was elected a director of the association last January. He became a member of the Board on May 11th. Mr. Neel is well known among the state highway officials of this country.

Splitdorf Puts Out New Model Magneto

The Splitdorf Electrical Co. announces the Splitdorf Model JK-1 magneto, especially suitable for small stationary engines.

The new magneto is described as a straight high tension magneto of the conventional *H* armature type. This is the shutter type in which the high tension coil, the condenser and the breaker rotate as a unit and the contact points are operated by a fixed annular cam.

Simplicity of design, ruggedness in construction and the inclosing of the working parts as protection from dust, mud and water, represent features of the new apparatus stressed by the manufacturers as distinctive features.

The model for single-cylinder engines, of course, conforms to the S. A. E. standards and its points of construction, are briefly summarized as follows:

The armature is of special construction, having a large laminated iron core on which are wound the usual primary and secondary wirings. These windings are treated with an insulating varnish under vacuum and then baked, thus reducing the chance of breakdown due to insulation failure.

The magneto frame is a rugged aluminum casting with embedded magnetic sectors on each side, machined to close limits, with drive-end plate cast integral.

The circuit breaker is of the balanced centrifugal high speed type, variable up to 30 deg. and fully adjustable.

The condenser is built up of alternate sheets of selected mica and tin foil. This assembly is compressed and treated with a suitable binder and baked. It is mounted on the armature head and forms part of the drive end assembly.

The terminal block is of the brush type, conventional in design and moulded of Traconite. It is doweled into the front plate and held in place by the safety gap screw and two upper end plate screws.

The collector spool is also moulded of Traconite and made oversize to eliminate the possibility of flash-over under compression or moisture. It is mounted on the breaker end of the armature.

The single permanent magnet is formed of the best grade magnet steel, carefully treated and accurately fitted.

Causes of Highway Accidents

A study of highway accident statistics for 1927 which has been made by the American Road Builders' Association reveals the fact that only 1.4 per cent of all fatalities are the result of highway defects. A total of 26,618 persons were killed, nearly all the result of careless or discourteous driving. The total fatalities chargeable in part to defects of street or highway was 383.

The statistical report follows:

Fatalities Caused Principally by Motorists

Total killed in 1927 11,765

	Pct.	
Inattention	32	3,765
Speeding	23	2,706
Traffic violation	20	2,353
Intoxication	9	1,059
Miscellaneous	16	1,882

Fatalities Caused Principally by Pedestrians

Total killed in 1927 11,367

	Pct.	
Children playing in the streets or crossing in violation of traffic regulation	32	3,638
Adult jay-walking	27	3,069
Inattention	16	1,819
Confusion	14	1,591
Other causes	11	1,250

Fatalities Caused Principally by Physical Conditions

Total killed during 1927 3,486

	Pct.	
Fog, snow or rain	37	1,290
Defect in vehicle	19	662
Skidding	16	558
Road defect	11	383
Strong lights	7	244
Poor street light	7	244
Confusion in dimming	3	105

The association plans the launching of an intense safety campaign during the latter months of 1928, to be climaxed by safety discussions at the 1929 Convention and Road Show.

Films on Road Improvement Distributed Free by Department of Agriculture

"Wheels of Progress" is the title of a new educational motion picture produced for free distribution by the United States Department of Agriculture. The film compares the highway transport conditions of 30 years ago with those of today and shows the tremendous strides that have been made toward rapid and individualized transit as a result of road improvement and the development of the motor vehicle.

Other films illustrate the methods of constructing the various types of Federal aid roads, and shows the spectacular and hazardous engineering work on the western National Forest roads. A special series of films, recently issued, and described in detail below, picture the superb scenic attractions of the national parks and the difficulties encountered by road builders while constructing motor ways into these mountainous areas. Other films show the progress of highway research and tests during the past decade.

All of these motion pictures are furnished free of charge, except for the regular transportation cost which the borrower is expected to pay both ways. They are available to the general public, as well as to state highway departments, road organizations, automobile clubs, colleges, schools, churches, theaters, and other agencies. In all cases it is necessary that a reliable person assume responsibility for such charges, and for the safe keeping, proper use, and prompt return of the films, all of which are of standard theatrical width.

Application for permission to borrow the films should be addressed to the Office of Motion Pictures, Extension Service, United States Department of Agriculture, Washington, D. C.

A $250,000 Per Mile Interurban Highway in Scotland

Heavy Construction on 42-Mile Road Between Glasgow and Edinburgh

By C. L. McKESSON
Materials and Research Engineer, California Division of Highways

THIS very unusual highway project 42 miles in length extending from Glasgow to Edinburgh in Scotland is of particular interest in that it is probably one of the most expensive pieces of road construction ever undertaken in Great Britain that it has been carefully designed to meet the designs of modern high speed interurban traffic, and that in type of construction it exemplifies the most approved European construction.

Cost and Quantities.—Some idea of the magnitude of the project will be conceived from the following table of costs and quantity: The total estimated cost is $10,878,262, including $1,776,272 for bridges and $942,962 for lands. The average construction cost, exclusive of bridges and right of way, is about $195,000 per mile. Excavation soft material 2,150,000 cu. yd., excavation rock 67,000 cu. yd., weight of Telford base 300,000 long tons, weight of surfacing 153,000 long tons, length of drains 82½ miles, maximum depth of cut 24 ft., maximum height of embankment 44½ ft.

On Relocated Alignment.—The road traverses a rather sparsely populated section and passes through several villages but no large towns or cities. Most of the road is on new location although old routes have been utilized for a portion of the way. Coal mining has been carried on for many years in the region traversed by the road and subsidence of the entire country side occurs from time to time. This unusual condition has been taken into consideration in the design of bridges which have been made adjustable by keeping the deck separate from the abutments in such places and by providing recesses in which hydraulic jacks can be placed for the purpose of raising the bridge deck from time to time as this becomes necessary. In one or two places where the coal has not already been mined the highway authorities purchased the coal "in place" from the owners with the understanding that it be allowed to remain and that lowering of the road be thus avoided.

Separate Traffic Lanes.—In the design of this improvement the engineers took into consideration the probability of urban development along the new route. They also took into consideration the difficulty which has been encountered in Europe and elsewhere in getting traffic to utilize to the best advantage a roadway containing a large number of traffic lanes. Experience on some very wide pavements near London had indicated that it is very difficult to secure a distribution of traffic on excessively wide roadways. As a result of their observations the engineers who designed this work have planned that the entire improvement ultimately have two traffic lanes each 30 ft. in width.

Details of Design.—On approximately four miles adjacent to Glasgow

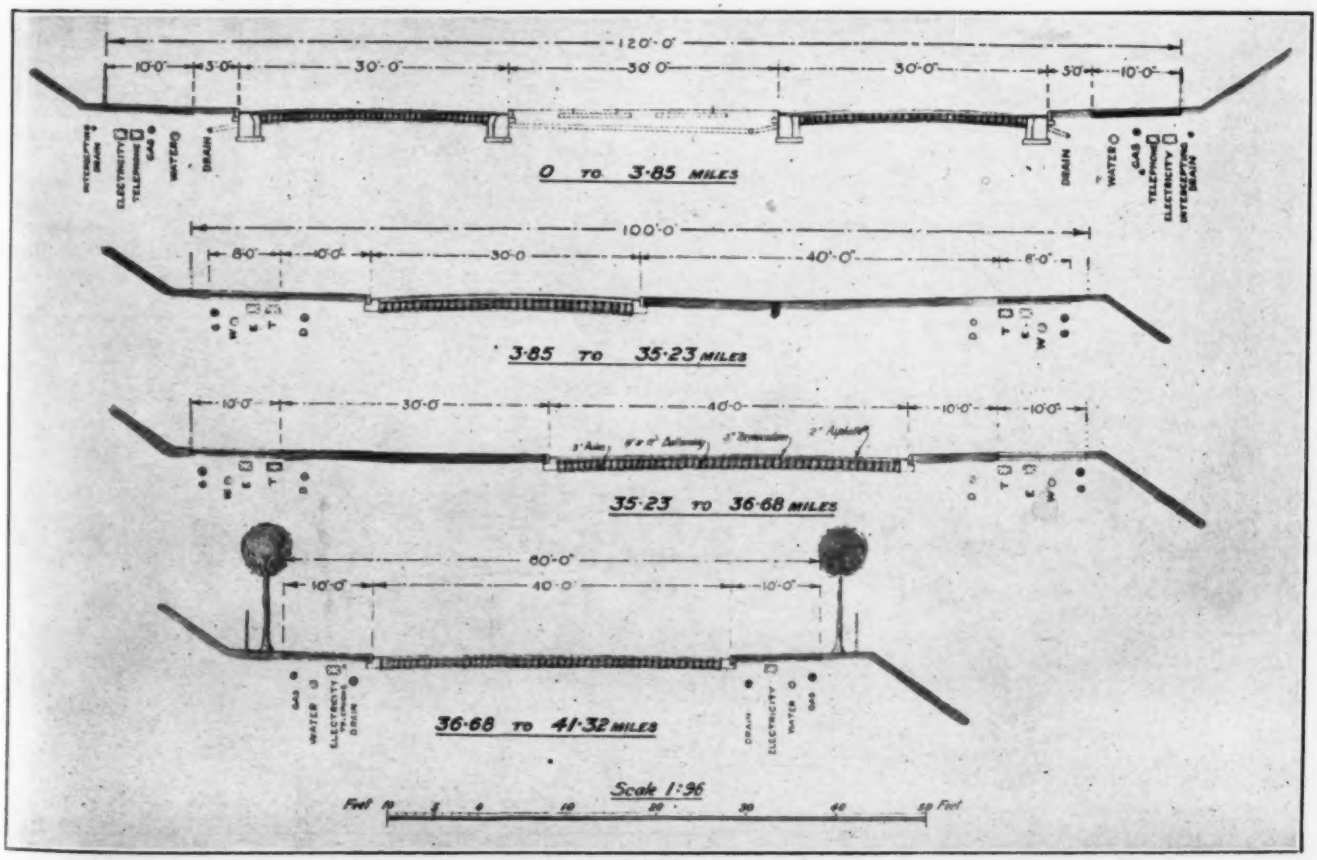


Fig. 1.—Typical Cross Section of the 42-Mile Interurban Highway Now U nder Construction Between Glasgow and Edinburgh

Fig. 2.—Telford Base Under Construction on Glasgow-Edinburgh Highway

the roadway has been graded to a width of 120 ft. between slopes. The typical cross section shows the 10-ft. sidewalks, a 5-ft. parking on each side for service pipes, two 30-ft. roadways with a strip in the center 30 ft. in width which it is expected may be used by an electric railway. On the next 31 miles the road is being graded to a width of 100 ft. between slopes and one 30-ft. roadway is constructed with one edge adjacent to the center line. The cross section also shows an 8-ft. sidewalk. On this section it is planned that future development, when required, will include the construction of another 30-ft. roadway separated from the first by a curb along the center line of the road. Figure 1 shows the typical sections and also indicates the type of construction.

In general, the road is to have a Telford foundation about 12 in. in thickness placed on a cinder sub-base.

Figure 2 shows this telford base under construction. A very heavy concrete curb has been constructed along each side of the roadway extending to the full depth of the telford base. This curb serves as a foundation for a 6 in. by 12 in. stone curbs which projects above the roadway with a 6 in. curb face. Figure 3 shows a section of the finished roadway on the Glasgow end of the project. After the telford base is thoroughly locked and filled the road is surfaced with 3 in. of tar macadam which is to be followed, after traffic has used the road for a time, by a 2 in. covering of asphalt concrete. This type of construction appears massive compared with some of our thin reinforced road slabs but is, in general, typical of the practice that has prevailed on important roads in France and Germany for many years. It is due to this heavy but more or less flexible base that it has been possible to build up road surfaces which successfully withstand continuous traffic, practically without load limit. It is nothing unusual to see heavy steam driven trucks with net loads of 30 tons or more traveling at high speed.

The surfacing on this road, first of tar macadam and then of asphalt concrete, is also more or less typical of English practice.

On some of the new grade reinforced concrete base is being constructed. This base has a cinder and stone subbase and is itself in reality a very substantial pavement. It is laid in 20-ft. panels with reinforcement top and bottom. The panels are constructed alternately and a reinforced concrete beam is built under each transverse joint. The concrete is 8 in. in thickness and of 1:2:4 mix. This very rugged concrete pavement is to have a cover consisting of 2 in. of asphalt concrete. It will be noted that the total thickness including sub-base reinforced concrete and asphalt wearing surface is 18 in.

Storm Drains.—A storm drain system is being installed and catch basins provided throughout the entire ro for handling storm water. Considering the great width of the improved roadway and the heavy type of construction it is not at all surprising that the total cost of this road should reach the stupendous average of $250,000 per mile. On the section adjacent to Edinburgh the total estimated cost is $369,854 per mile.

Intersections. — The chief engineer has given much attention to the proper design of intersections and also to the matter of securing proper sight distances on vertical curves. Figure 4 shows the standard solution which he has applied to the intersection problem. The intersections, where completed under this plan had a very pleasi appearance and seemed to insure r sonable sight distances.

The method of using the standa solution shown in Fig 4 is as follows:

The center of the 30 ft. carriageway and of the intersecting road are drawn and are found to intersect at the point A. With A as center and a radius equal to four times the width of the carriageway of the intersecting ro (minimum 70 ft.) the "locus circle" drawn on which four points B. B. B. are found equal distant from the curbs of the 30 ft. carriageway and of the intersecting road. With these point as center the curbs are swept in. If the angle of intersecting is such that any of these corners are greater than about 135° the radius of the "locus circle"—in these corners only—is increased by 10, or by 20 ft. if greate than about 150°.

To ascertain the splay angle on the fences a point C is found on the center line of the intersecting road at a distance square off line of the new road fence not less than F, the distance between the fences of the intersecting road. The distance Y between the point C and the point D where the center of the intersecting road crosses the line of the new road fence is set off right

Fig. 3.—Section of Finished Roadway on Glasgow End of Project. The Sidewalks Are of Tar Macadam

d left along the fence, thus giving the points E. E. The splay required lies along the lines Ce CE.

In every case, of course, it is necessary to arrange the position of C so that the splay is set far enough back not to reduce the width of the footpath.

Sight Distance on Vertical Curves.—The following is quoted from the chief engineer's description of the design of the vertical curves:

"Vertical curves at sags are to be parabolic. The length of the curve is to be generally 150 times the algebraic difference of the grades per cent (equivalent to a circular curve of 15,000 ft. radius). Vertical curves at ummits are to be parabolic. The ngth of the curve is to be 120 times algebraic difference of the grades cent (equivalent to a circular curve 12,000 ft. radius) except at bridge or other crossings where it is necessary or desirable to keep down the amount of banking, where a length of 80 times the algebraic difference of the grades per cent is desirable and a length of 50 times will be the ultimate minimum (equivalent to a circular curve of 8,000 and 5,000 ft. radius, respectively). With such vertical curves at summits, the minimum lengths of the line of sight to the horizon from a point in a motor car 5 ft. above the ground are respectively 346.4 ft., 282.8 ft., and 223.6 ft., and the distances at which two motor cars 5 ft. high become mutually visible are 692.8 ft., 565.6 ft., and 447.2 ft."

This important highway project is conducted under the general supervision of Sir Henry Maybury, chief engineer of transport. The proposal of plans, details, and the construction of the work is carried on under the personal direction of Mr. D. A. Donald as chief engineer. It is to these gentlemen and to Mr. Wright, assistant engineer, that the writer is indebted for the information which he obtained regarding the project and for the opportunity to make this inspection.

Acknowledgment.—The matter above is taken from a paper presented on March 10 by Mr. McKesson at a meeting of the Western Association of State Highway Officials.

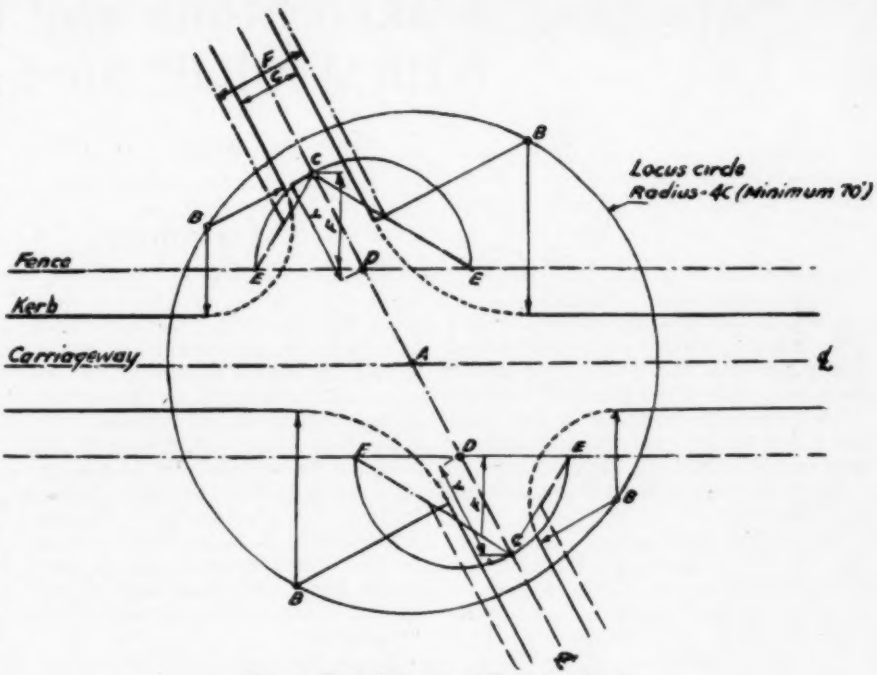


Fig. 4.—Typical Layout of Road Junctions

Cost of Blade Grading Work

Mr. Andrew Wallubait, Assistant County Engineer of Dallas County, Iowa, states, the costs listed in the following table are operating costs only and do not include costs of tractors or any depreciation whatsoever. The county is divided into three districts in charge of one of the supervisors. Each crew works in its own district. The operators are paid a flat rate of $0.65 per hour for actual working time only, grading, moving and repair, etc. They furnish their own transportation and pay for their own mess.

All the grading is staked by the engineer who has charge of all the crews. Where team work is necessary this is done first and followed up by the machine. The roadbed has been made 22 to 24 ft. depending on the importance of the road. Nearly all the work is back-sloped and left in good shape. The repairs listed under Tractors Nos. 2 and 4 in Crews Nos. 1 and 2, were spent before the work opened up and a short time later these tractors were traded in on the new tractors, Nos. 1 and 3 as shown. Crew No. 1 graded about one mile with Tractor No. 2 and Crew No. 2 graded about two miles with Tractor No. 4 before the new tractors were shipped. Crew No. 3 used Tractor No. 5 all season as shown.

The operators and all repairs, etc., are paid for out of the County Road Fund and then the Townships are charged a flat rate of $4.00 per hour for the actual time spent on grading only.

The miles shown under each crew are the actual miles upon which they worked. Crews 1 and 3 had the better part of the county while Crew No. 2 had the more hilly part and more banks to fight.

Blade Grading Costs, 1927, in Dallas County, Ia.

Items	Crew No. 1 Harper & Campbell Tractor No. 1	Crew No. 1 Harper & Campbell Tractor No. 2	Crew No. 2 Woods & Whitney Tractor No. 3	Crew No. 2 Woods & Whitney Tractor No. 4	Crew No. 3 Randall & Sisberry Tractor No. 5	Totals, hours
Hours of Labor						
Twp. grading	2,160		1,849		16,888	5,697
County grading	60		270		70	400
Moving	369½	40	258	70	144	881½
Engine repair	117	306	385	385	436	1,629
Blade repair	175		227		135	537
Total, hours	2,881½	346	2,989	455	2,473	9,144½
Grand total, hours		3,227½		3,444	2,473	9,144½
Parts						
Tractors	$ 58.32	$482.48	$ 62.09	$154.08	$ 163.19	$ 870.16
Graders	188.77		575.40		309.94	1,074.11
Gasoline						
Gallons	6,219		6,368		4,840	17,427
Per gallon	$ 0.162		$ 0.148		$ 0.146	$ 0.153
Total	$1,012.82		$ 947.47		$ 710.95	$ 2,671.24
Oil	$ 169.10		$ 85.27		$ 139.58	$ 393.95
Grease	$ 36.20		$ 14.40		$ 25.15	$ 75.75
Waste	$ 4.95		$ 5.28		$ 2.20	$ 12.43
Total	**$4,000.51**		**$4,082.59**		**$2,958.46**	**$11,041.56**
Miles graded	44*		34*		31*	109
Cost per mile	$ 90.92		$ 120.07		$ 95.41	$ 101.30

*Crew No. 1 backsloped all but 4 miles. Crew No. 2 backsloped all but 2 miles. Crew No. 3 backsloped all but 2 miles.

Road Construction in Argentina.—A recent report of the U. S. Trade Commission at Buenos Aires states that Argentina spent $5,437,700 on road and bridge construction and maintenance in 1927 out of national funds. It is estimated that an equal amount was expended by the provinces from their individual provincial budgets.

The Gasoline Tax in Mexico.—The Mexican federal government's road tax on gasoline is said to have produced $7,500,000 U. S. currency during 1927, and about $5,000,000 of this amount is said to have been set aside for work during 1928 on the road from Laredo, Texas, southward in the direction of Mexico City.

Salvaging Broken Stone and Gravel Roads With Asphalt Surface

Methods Employed for Laying Various Surfaces

By WM. H. RHODES

Southern Branch Manager, The Asphalt Association, New Orleans, La.

ASPHALT surfacing lends itself to many methods of construction. The purpose of this paper is to briefly mention a few of the standard methods of design and construction that may be followed to improve a gravel or broken stone road.

These various steps in betterment are as follows:

1. Surface Treatment
   a. With cold asphaltic road oil.
   b. With hot asphaltic road oil.
2. Asphaltic Macadam (Penetration).
3. Asphaltic Concrete.
4. Sheet Asphalt.

Surface Treatment With Cold Liquid Asphalt.—The purpose of such a treatment would be to lay the dust and secure penetration of the gravel, the treatment acting as a binder course for a later treatment of hot oil. The principal advantages of this method are that the oil does not require a heating plant at the car nor a pressure distributor to spread it on the road. The disadvantages are that it does not form a mat or smooth surface and is of only temporary value if neglected. The oil coats each pebble with a film of asphalt and penetrates the surfacing to a depth of from 1 to 2 in. In Oklahoma we found that this treatment materially aided the stability of the gravel surface, it laid the dust, and as stated above, made an ideal first treatment to be followed later by a hot oil application. We used an oil containing about 60 per cent asphalt and spread at rate of 5/10 gal. per square yard.

The procedure was to first patch any depressions in the existing gravel surfacing, using if possible, as patching material the same kind of which the road was originally built. Then the surface was thoroughly bladed and shaped to the desired cross-section, using a heavy road machine. Traffic was allowed to use the road for several days so as to thoroughly compact the patches. Then the gravel was reshaped and the oil spread. Traffic was kept off for 24 hours. After a few months of wear I would recommend that the treatment be followed by a hot application. Best results will be had from the cold oil treatment on sand gravels, where the oil will penetrate. On closely bonded clay gravels I would not recommend cold oil treatments.

Surface Treatment With Hot Road Oil.—This is the so-called carpet treatment that is very generally followed both in towns and on country highways where it is desired to lay the dust, make a smooth waterproof surface, and conserve the gravel. If especial care is taken this treatment gives very excellent results and the cost is not excessive. It should be generally understood however by all concerned that in no sense should it be classed as a pavement. Wherever weak places develop in the gravel subgrade depressions will appear in the surface, requiring prompt maintenance.

Before attempting any treatments or improvements it will be well to thoroughly test the gravel or rock street as to thickness. It is a waste of time and money to attempt to treat a thoroughly worn out surfacing. The success of this oiling depends on a substantial base, firm enough to hold up under traffic provided the covering is waterproof. As all of you know, a gravel street when saturated is in its least stable condition, but if it can be kept dry by waterproofing a somewhat less thickness of compacted gravel can be used than would be needed to hold traffic without such treatment. Should your tests show your gravel streets are thin they can be brought to the desired thickness with additional gravel and permitted to consolidate under traffic.

The asphaltic oil now used most generally is of from 175 to 250 penetration, although many states still demand the old 80 per cent road oil. These oils require heating to be withdrawn from the tank cars and require pressure distributors for spreading. The oil works best when heated to about 275° F.

After the street has been carefully patched, brought to true subgrade cross-section and compacted by traffic, we then are ready to apply the oil. The street should be closed to traffic. First, with a rotary broom sweep all the dust, dirt or loose gravel to the gutters or ditches. In case of a macadam road any crusts of dirt or dust should be broken off and the surface swept clean. After sweeping, the pebbles or rock should be left protruding somewhat so as to better give a hold to which the oil can cling. Then the asphaltic oil is spread with the distributor at the rate of about 5/10 gal. per square yard. On this is cast the cover material, which is usually washed pea gravel or clean rock chips, none of which are over ¾ in. A fair estimate of cover material is that 1 cu. yd. will cover about 70 sq. yd. or about 40 lb. of rock will be needed to the square yard of treatment. The spreading of the rock is usually done from piles previously spread along the street on the sides, the piles closely placed so that the shovellers can easily cast. Several contractors state they have used mechanical spreaders with success, but I have never been able to do so. This method of treatment is probably the cheapest and simplest of all surface treatments. The excellence of the results will depend largely upon the uniformity of spread by the distributor operators. Should it be necessary to stop to clean the nozzles of the machine, or for other causes the machine stops, the oil should be cut off promptly. Otherwise there will be a "fat" place or bump where the asphalt dripped and puddled.

Sometimes where additional thickness of surface is necessary we have applied a second coat following exactly the same procedure as the above. This is not usually to be recommended, however, as such a mat under traffic may become uneven and break. The great tendency in this work is to get the mixture too "fat," that is, with the asphalt content too great through not adding enough covering material. You should keep the oil thoroughly covered and as the black begins to show through the loose material on top, add more until all of the oil has been taken up.

Another manner of preserving gravel surfaces is the so-called inverted penetration method. This has been used extensively in Texas. The method is somewhat the same as the surface treatment, except that the covering material is much larger rock or pebbles. More asphalt is used, probably about ¾ gal. per square yard. The first course is thoroughly rolled after the rock has been added and a second application of asphalt is made of about ¼ gal. per square yard. Fine material is then used to seal tight the surface voids. This inverted penetration method is an adaptation of the asphalt macadam, or penetration method.

There are many other methods followed by various engineers and state highway departments with slight changing of the several operations. With the single hot oil treatment the asphaltic mixture will be about one-half inch. With the cold oil treatment followed by the hot oil treatment a mix-

ture of at least 1 in. and possibly up to 2 in. will be had. These treatments can be classed as temporary and are to be used more or less as a stop gap while efforts are made to bring out a program of paving. They are first steps toward progressive construction.

Asphalt Macadam (Penetration).—With the exception of Louisiana and Mississippi most states in this section have an abundance of rock suitable for street construction and consequently we find many towns where waterbound macadam streets have been built and been in service for many years. With the heavy wear of modern traffic the macadam surface has become so worn out and ravelled that some steps should be taken to secure either a new pavement or so treat the existing macadam as to provide a new surface. The simplest manner of providing a new asphaltic wearing surface is by the penetration method.

Public officials are always faced with the necessity of conserving funds. Few engineers have an unlimited treasury they can dip into for their street programs. They must build a pavement adequate for the traffic and yet the cost of which will be within their means. Penetration surface probably exceeds any other type of asphalt surfacing on the highways throughout the country.

This method is to be recommended where suitable rock is inexpensive and where the old macadam street can be used as a base, where funds for the improvement will permit asphaltic concrete should be recommended in preference to penetration macadam as the superiority of hot mix pavement over a penetration macadam is marked.

There are many considerations in using the old road as a base. There is the question of thickness of the old macadam, of the elevation of the center and also the crown and cross-section. Also the question of curbs or headers.

The thickness of the old macadam must be enough to act as a base for the new pavement. Of course many engineers reason that if the road before improvement was strong enough to carry the traffic it surely will be ample when a surfacing is added. This opinion will be true more often than not, but you should bear in mind that a new street always attracts more traffic and heavier loaded traffic. That is a problem each city or state engineer must solve for himself from his own experience in the city concerned. It is not possible to say what should be the minimum thickness. That depends on the sub-soil conditions and the type of traffic, but I do not believe that under any conditions it should be less than 5 in. In salvaging the old macadams in Nashville, Tenn., I believe 8 in. is the minimum and the surfacing is laid directly on the base.

Where the thickness of the base is not enough, additional rock may be added. This can be done by lightly scarifying the old surface and adding the necessary rock before thoroughly rolling.

In many cities the center elevation of the street is too high to permit the adding of the pavement without cutting. Most of our streets have been macadamized or gravelled by piling up the material in the middle of the street. Usually this has given a very high crown and the top of the roadway is excessively rounded. Where this is the case, and the thickness of the material at the center permits, the center should be scarified and the excess either used in building up the quarter points or the sides. Of course, if the curb and gutter is already in, as I find is usually the case, it may be necessary to either tear the curb and gutter out to establish a new grade, or else remove and lower the old macadam. Where the latter course is necessary the value of saving the old macadam for a base still remains, as it would still be as necessary to remove the rock and excavate should any other pavement be laid. The cost or value of the rock would be saved.

In cities a curb or header has been found necessary. This is due to the nature of the traffic, which is constantly turning off the pavement or mounting up on the pavement from the gutters or ditches. Usually this header or gutter is of concrete. To the contrary, on country roads and parkways I do not believe concrete curbs or headers are necessary. There the traffic follows more along the line of the pavement. There is very little running on and off as in a city. The only advantage a concrete header gives is to help brace the edge of the pavement to withstand the weight of traffic. Traffic on country roads divides, each vehicle stays on its own side and as a consequence the wheels pass over the same narrow lanes of pavement. In Oklahoma we found that traffic uses a lane about 2 ft. wide for each wheel and that the center of that line is about 18 in. from the edge of the pavements. Heavily loaded trucks hug the edge more closely than other vehicles. Their loads are usually bulky and by crowding the edge passing traffic has more room. Such concentration of loading on the edge of the pavement naturally has a tendency to rut, and also to shove out. All of us have seen this very thing happen, and it happened with roads having headers as well as those without. To overcome this weakness modern practice has adopted the thickened edge for asphalt surfacing on gravel or macadam bases where such thickening is practicable. This increased thickness, or inverted curb, as it has been named, has been very successful. In Oklahoma we had several miles of asphaltic concrete laid on an old gravel roadbed without curbs. The extra binder required to bring the cross-section of the old gravel road to the proper design for an asphalt surface was enough added thickness to support all traffic. There was almost no pushing out. The same condition holds on the experimental road built by the Louisiana Highway Commission. The old gravel road was widened to 18 ft. by two strips of asphaltic concrete. This thickened edge has held the traffic with almost no depressions. In Caddo Parrish, La., where macadam bases are the standard, no curbs are now used and yet the surfaces carry very heavy oil field traffic without serious defects appearing.

Method of Laying a Penetration Macadam Surface Course on a Macadam Base.—The customary thickness desired is about 2½ in. The aggregate may consist of crushed rock or slag of proper toughness and density. The sizes of the stone should be graded from 2½ in. down to ¼ in. and should be separated into three sizes. The coarse stone being from 2½ in. to 1 in., the medium size stone from 1¼ in. ¾ in. and the fine stone for the seal coat ranges in size from ¾ in. to ¼ in. In grading the aggregate the greater portion of each classification should be of the larger sizes.

The asphalt used should usually have a penetration of from 60 to 120, according to the nature of the traffic and the ranges in temperature where used. I believe that in the past the practice has been to use asphalt cement having too high penetration and as a consequence in high temperature the surfacing became softer than it should. Georgia, for instance, has been specifying 60 to 80 penetration asphalt and their new specifications set the limits at 60 to 70. I have heard several criticisms along these lines in Texas, especially where the sun gets pretty hot in summer.

The method of construction is briefly as follows:

On the prepared base the coarse rock is spread to a uniform depth of 2½ in., care being taken that there are no dirt pockets. This course is then thoroughly rolled with a 10-ton roller until the stones are tight enough to permit a truck to pass over without forming deep ruts.

On this first course the hot asphalt cement is spread, using a pressure distributor and applied at the rate of about 1.6 gal. per square yard. Extreme care should be taken to secure a uniform distributor. In case a pressure distributor is not available hand pouring pots are used.

While the asphalt cement is still hot a thin uniform layer of the medium size stone is cast over the road so as to completely cover the asphalt and sufficiently fill all voids. This course is then rolled thoroughly until as much of the stone as possible has been worked down into all the openings in the larger stone.

The surplus stone is then broomed off and another application of hot asphalt cement made at rate of ½ to ¾ gal. per square yard. On this is spread the dry fine rock and then road again thoroughly rolled. The finished road should be absolutely free from ruts or any depressions.

A penetration macadam built carefully as above described on an adequate macadam base will make a very satisfactory pavement at a reasonable cost per square yard.

Asphaltic Concrete.—The use of asphaltic concrete in reclaiming macadam roads is very general. The advantages of hot mix over penetration are many. The relative merits of fine aggregate or coarse aggregate asphaltic concrete will not be touched in this paper. Most of you are familiar with them. In asphaltic concrete with its properly graded aggregates we get a dense mixture and a uniformly mixed pavement from a hot mix asphalt plant. Such surfaces are among the best in the world as to long life, low maintenance cost and smoothness.

The manufacture of asphaltic concrete and the methods of spreading, raking and rolling I will pass over through lack of time.

This type of pavement is especially adapted to communities where there is an abundance of gravel, and where gravel is cheap. Asphaltic concrete with gravel aggregate, on a gravel base, are very commonly used together.

Usually where we find a majority of the streets or roads in a community have been built of gravel instead of rock it means that gravel in that locality is much cheaper than rock, and because of these conditions we find gravel roads reclaimed or surfaced with asphaltic concrete.

The procedure followed in shaping the old gravel bases is very similar to that described for macadam bases. The thickness of the base, however, probably should be more than 5 in. where traffic might be heavy. Satisfactory results have been had where the gravel was 6 in. compacted.

In case the old gravel road is not thick enough to be used as a base the laying of a binder course or black base is now very generally adopted and followed. For strength it is more or less a general practice to consider 1 in. of black base the equivalent or better of 2 in. of compacted gravel. Testing of the depth of the old gravel street is necessary and with this knowledge the engineer can design the base so as to give the required strength to support the top course of asphaltic concrete, using the gravel base supplemented with the black base.

Asphaltic concrete surfacing is generally laid 2 in. thick.

Sheet Asphalt.—The procedure followed in reclaiming old gravel or macadam pavements when sheet asphalt is used as a surfacing course is very similar to that outlined above for penetration macadam and asphaltic concrete; especially so with reference to the shaping of the old road, patching and preparation of the base and making ready for the surfacing course.

Sheet asphalt is usually laid with a binder course, although this may be dispensed with if the foundation is a black base. Several of the southeastern states are now reclaiming their worn out gravel road by topping the old road with a 3 in. binder course on which is spread a sheet asphalt wearing surface 1½ in. thick. These roads are giving very excellent results.

In this connection I wish to warn against using a closed binder. A more or less open binder must be used, especially where gravel is used as coarse aggregate. The percentage of sand should be cut to a point where the surface texture of the compacted binder is distinctly rough, or otherwise slippage of the wearing course on the binder may occur under traffic. I have been told that last year the State Highway Department of Michigan experienced considerable trouble along this line in connection with the use of binder or black base course under fine aggregate asphaltic concrete and the trouble has been remedied by cutting the percentage of sand used in the mix.

Sheet asphalt has also been very successfully used in resurfacing brick and granite block pavement. The usual procedure has been to true up the unevenness of the brick surface with a binder before laying the topping. Where there are car tracks a few rows of bricks adjacent to the tracks are removed. Also two or three rows of brick are taken up along the gutter. With the binder the desired shape or cross-section of the base is then secured at the edges which will permit the molding of the sheet surface to fit the gutter and the car tracks. In this section of the country we have several very excellent examples of such resurfacing of old brick streets with sheet asphalt. The easy rise at the gutter line fitting the gutter edge to the surfacing is not objectionable and does not seem to be noticed.

Acknowledgment.—The foregoing is an abstract of a paper presented at the last annual convention of the American Society for Municipal Improvements.

Cost of Tractor Blade Grading

Mr. R. T. Johnson, county engineer, Knoxville, Iowa, sent us the following report on the cost of blade grading operations. Three outfits are represented:

No. 1—Rented, 40-60 tractor at $3.60 per hour running time. Includes everything ahead of grader tongue. A 12-ft. blade grader and back sloper, owned by county.

No. 2—County owned and operated 40-65 tractor and 12-ft. blade grader with back sloper.

No. 3—County owned and operated 40-60 tractor and 12-ft. blade grader with back sloper.

Rates of Wages

Tractor and grader operators	$0.65 per hr.
Man and team	$0.55 to 0.65 per hr.
Single hand	0.30 to 0.40 per hr.
Subforeman	0.50 per hr.

Gas and oil furnished to men for transportation in their own cars.

Table I was prepared by Mr. Johnson to present to the board of supervisors. The totals of columns 1, 2 and 3 are not the same figures as will be found in the line of the table entitled "Total Payroll Dollars." The figures in the line marked "Total" show actual total cost, including everything but depreciation and interest on the investment. The figures in the next to last line are the totals of the "Payrolls" only; they represent labor only.

Cost of Small Fresno Job

This little job was done in Marion County, Iowa, upon instructions of Mr. R. T. Johnson, county engineer. Mr. Johnson states that county owned equipment was used, as plows, fresnos and slips.

The cut upon which the teams worked was 910 ft. long and 1,281 cu. yd. of black prairie loam was moved. The earthwork cost was $601.38, which makes a cost per cu. yd. of $0.47. Clearing and grubbing cost $20.25, placing a culvert pipe cost $10.50, moving a fence cost $16.25, making a total miscellaneous cost of $54.00. This is $0.042 per cu. yd., making a total cost per cu. yd. for the job of $0.512.

Rates of wages were as follows: Foreman, 50 ct. per hr.; 1 man and team, 65 ct. per hr.; 4 men and teams, 55 ct. per hr.; 1 single hand, 40 ct. per hr.; 1 single hand, 35 ct. per hr.

Table I.—Tractor Blade Grading—Season 1927, Marion County, Iowa

Items	Outfit Costs by Number			Average Costs per Mile		
	1	2	3	1	2	3
Tractor repairs	.....	$ 647.33	$ 462.71	.....	$ 29.40	$ 21.40
Grader repairs	$ 288.02	158.36	26.50	$ 7.50	7.10	1.23
Fuel and lubrication	157.45	1,203.60	828.30	4.12	54.60	38.45
Tractor operator	.....	706.51	786.50	.....	32.00	36.40
Grader operator	1,227.64	813.15	799.50	32.00	36.80	37.02
Rentals	3,304.80	.....	.....	86.20	.....	.....
Sub totals				$129.82	$159.90	$134.50
Cook	94.00	158.00	.....	2.45	7.13	.....
Man and team	2,541.65	1,929.10	2,332.15	66.30	87.30	107.80
Hardware	647.97	256.38	118.49	16.90	11.57	5.45
Miscellaneous	37.83	11.50	65.14	.98	.50	3.05
Total costs	$8,299.36	$5,883.93	$5,419.29			
Cost per mile				$216.45	$266.40	$250.80
Total miles				38.3	22.1	21.6
Total payroll dollars	$8,011.34	$5,078.24	$4,930.08			
Labor cost per mile of grading				$209.10	$230.00	$227.10

Five Miles of Concrete Pavement Laid By Batch-Box Method

Notes on Equipment, Methods and Forces Used on State Aid Job

ONE of the several important state highway jobs now under construction radiating from the city of Chicago is that known as 22nd St., or Route 390. At present, the Chicago Heights Coal Co., Chicago Heights, Ill., contractors, are paving about 5.38 miles of this highway. The work starts at First Ave. and ends at York Road. While not one of the most important highways in the district, it is one widely used by local traffic and acts to relieve congestion on parallel routes. Formerly paved with macadam, it had outlived its usefulness and had deteriorated to the point where maintenance would not be worth while. The new pavement is of reinforced concrete, of standard state section, and will be 20 ft. wide, except at intersections, where it has been widened to 40 ft. The section used has thickened edges, 9 in. thick for 1 ft., and then thinning to 7 in. in a width of 2 ft., which thickness is then maintained to the centerline. The centerline of the slab is divided by a steel center strip. A temperature bar is placed in the thickened edge. The widening at the intersections is done by adding 10 ft. shoulders, separated from the main pavement by steel parting strips of the same design as used in the centerline.

Fig. 1—Final Grading with New Trench Machine and Austin Pup

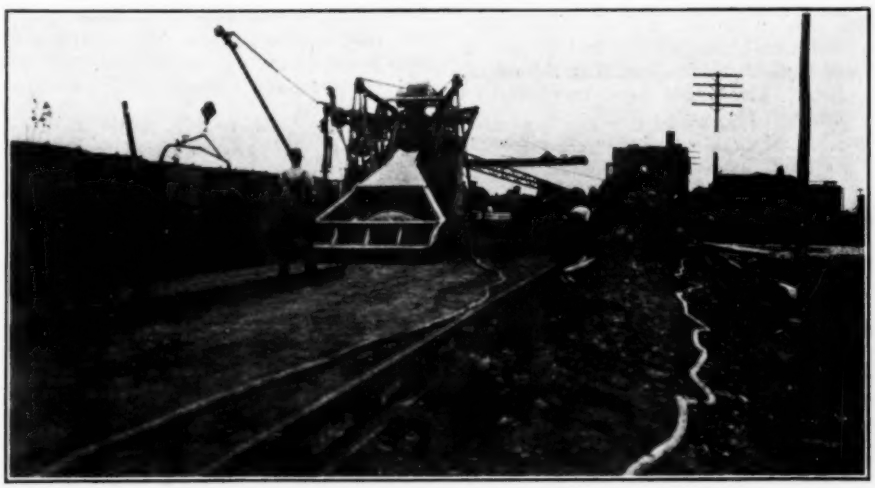


Fig. 2—View of Paver with Boom About to Pick Up Batch Box

Rough Grading.—Rough grading, intended to remove old surface and bring the subgrade to within plus or minus two-tenths of a foot of the desired finished subgrade, was done with two elevating grader outfits. For a majority of the work only one outfit was used, while two were employed for a part of the time. The total material to be moved was about 35,000 cu. yd. Balance points were far apart, the average haul being about 1,200 ft. Each grader

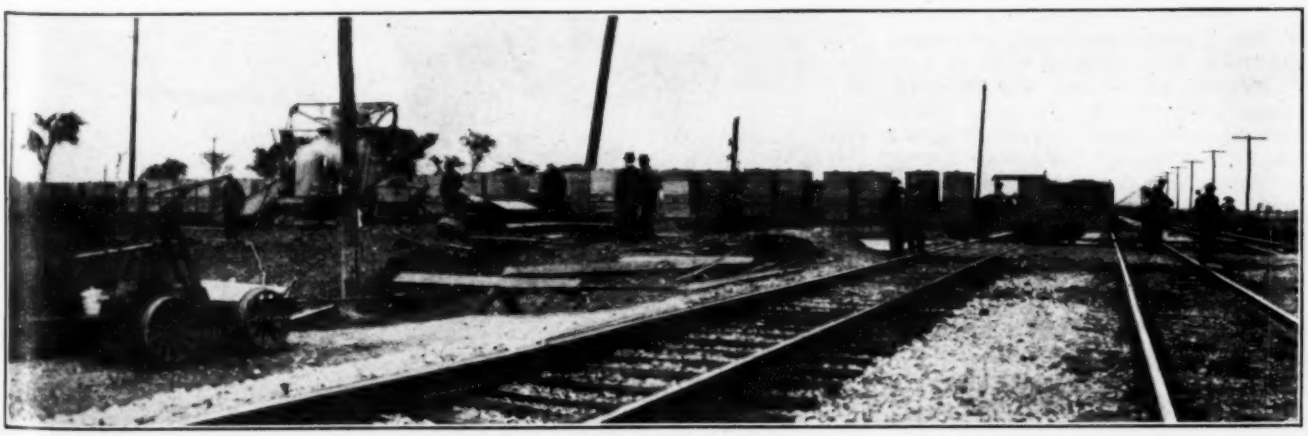


Fig. 3—View of Paving Operation Showing Locomotive, Cars, Batch Boxes, Paver, and Finishing Machine. Note How Tracks Are Blocked Up Over Railroad Crossing, with Man Stationed at That Point to Remove Track When Trains Come Along

outfit, working 1 eight hour shift per day, consisted of an Austin elevating grader hauled by a Caterpillar 60 tractor, 8 dump wagons with three-up team, and a two-up morman team at the dump. The crew then would consist of a foreman, with 9 skinners, a tractor operator, a grader operator, a dump man, a barn boss, a blacksmith, etc. With this organization, the average performance, handling old macadam and clay, was 600 to 700 cu. yd. per day.

Subgrading.—Subgrading was done in a simple manner. The actual cutting and filling was done with an A. W. French "Nu-Method" Finish Grader working on the road forms. This grading was followed with a rolling with an Austin Pup. The finish grader used is a gasoline powered device that plows and blades the subgrade and strikes it off with a template, all automatically. The results on this job were observed to be quite satisfactory, with about the proportion of soft spots that should be expected in this type of soil. Such soft spots as were found could be easily filled with a shovelful of clay ahead of the roller.

Batching Plant.—Located so as to give a maximum haul of batches of about 2½ miles, a batching plant was set up to be served by trucks. This consisted of space for stockpiles, a set of Johnson bins, cement trailers, and an Erie 1 yd. crane for handling the aggregates. Aggregates were trucked from a quarry 1½ miles away by 2½ ton trucks, using 3 on sand on 2 on stone. The sand and stone would then be dumped onto the stockpile, holding on an average 10 cars of each aggregate, and loaded into the bins by means of the crane. A 6-wheel Anderson truck with three trailers was used to haul cement from the cars on a team track about 1½ miles distant. The trailers would hold about 240 sacks of cement in one load. One trailer load would be in transit while one would be unloading to the batch boxes at the plant and the third would be in the process of loading at the car.

Hauling to Paver.—Batches were hauled from the batcher plant to the paver in batch boxes. Two boxes were loaded on each car, of which some were Westerns and some were Lakewoods, and trains were made up of 20 cars, or 40 batches, hauled by 8-ton Plymouth gasoline locomotives. Three such locomotives were used. The track gauge was 24 in. The batch boxes used were those manufactured by Lakewood. This type of equipment proved feasible on this job by eliminating the cutting up of the subgrade by trucks, by keeping a steady stream of materials arriving at the paver, which eliminated waiting for batches, and because traffic tieups were avoided. The contractor was of the opinion that batch trucks would have been more costly to use on this particular job.

Paving Equipment.—The paver used on this job was a new model Koehring 27-E machine equipped with a boom for handling the batch boxes. While being operated by a substitute operator at the time the job was visited, the concrete appeared satisfactorily uniform and the mixing cycle was averaging 80 seconds with a specified one minute mix. Lost time was not excessive, since a good supply of batches was on hand at most times, and the performance was reported to be about 400 batches or 800 lin. ft. per shift with the regular operator. The lost time observed was mostly due to shifting the paver and to waiting for an empty train to pull back to the passing track and a full load to pull up to the paver. This passing track was kept as near to the paver as possible in order to minimize this lost time. The mix used was 1:2:3½, with enough water to give a slump of less than 2 in. At the intersections 3 additional sacks of cement were added to each batch in order to secure normal strengths at 7 days instead of 28 days in order that the intersections would not remain blocked for very many days.

Pipe Line.—Water for the batches and for other purposes was taken from the Des Plaines River and pumped to the paver through a 2 in. pipe line by a 500 g.p.m. 3 cylinder C. H. & E. gasoline motor driven pump. This pipe line was found to give plenty of water, since no great amount was needed for curing.

Finishing.—As rapidly as it was deposited on the subgrade and spread by the puddlers, the slab was finished with an Ord finisher and the usual floats. As rapidly as finished, the slab was covered with burlap and this covering wet down thoroughly and kept wet by sprinkling. This covering was kept in place until the following morning, when it was removed and calcium chloride was spread over the surface at the rate of 2½ lb. per square feet.

Subgrading Crew.—The crew on the rough grading work has already been enumerated. The fine-grading crew consisted of

1 Superintendent
1 Timekeeper
1 Subgrader operator
1 Roller operator
2 Form setters
2 Laborers

The Batcher Crew.—Men at the batcher plant and hauling materials and batches, were as follows:

6 Truck drivers
2 Cement hands at car
4 Cement hands loading boxes
1 Crane operator
1 Batcher
1 Fireman, on crane
1 Checking loads
3 Locomotive operators

The Paving Crew.—At the paver and in the finishing operation, the following men are used:

1 Foreman
1 Mixer operator
1 Finishing machine operator
1 Hoist man
2 Dumpers
2 Finishers
3 Puddlers
1 Laborer setting steel
1 Water boy

Supervision.—Supervision on jobs being done by the Illinois State Highway Department is quite thorough. Besides setting grade stakes and generally supervising the work, the project engineer keeps accurate count of the proportioning at the batchers, the number of batches sent to the paver, the time of arrival and departure of batch trains, the time of dumping, the time of start and end of mixing, the time of dumping the batch, lost time and cause, water

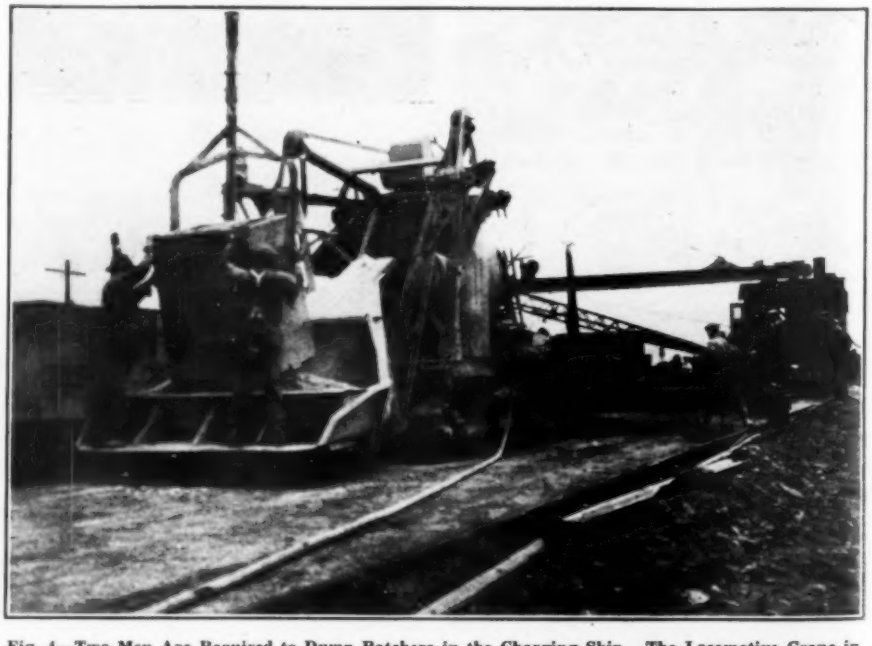


Fig. 4—Two Men Are Required to Dump Batchers in the Charging Skip. The Locomotive Crane in the Background Is Being Used by the Railroad in Reballasting the Track at the Crossing

Fig. 5—Curing Is Done with Wet Burlap and Calcium Chloride. Burlap Is Handled on Batch Cars as Shown

content of the mix, evenness of surface, and other pointers. He takes frequent slump tests and specimens for beam tests, and otherwise observes everything that goes on at the work. Strict adherence to specifications is enforced, and careful record of performance is kept in order that the engineer may be satisfied that the work is progressing efficiently. As a result, the work such as that described is well done.

The contractor on this job is the Chicago Heights Coal Co., of which W. J. Orr is secretary and in charge when the work was visited. The state, which pays for the entire job and furnishes the cement, is represented by George Lamb, district engineer; Oscar (Jack) Frost, resident engineer; George Squires, engineer of construction; R. M. Dillon, supervising engineer; and Norman Saper, junior engineer.

Rate of Deformation of Concrete During Test in Compression

From May Technical News Bulletin

The rate of deformation of materials during strength test affects the strength values that are obtained, an increase in rate of deformation resulting, in general, in an increase in strength. This characteristic is apparently connected with the flow or the rate at which the particles of the body will readjust themselves to new positions during strain and is an entirely different phenomenon from the influence of the inertia of the mass of a structure which will permit a much higher instantaneous loading, such as will result from an explosion, than will be statically sustained. Tests by Abrams, described in Proceedings of the American Society for Testing Materials, Vol. XVIII, 1917, p. 364, have shown the relation between the strength of various concrete mixes and the velocity of the testing machine head, the actual deformation of the concrete itself not being given.

In connection with the tests on the Santeetlah Dam cylinders, described in Technical News Bulletin No. 129 (January, 1928), several of the 6 in. cylinders were tested with plaster of Paris caps on both ends, and several were tested without capping, the ends having been previously ground to a true plane surface. The idle speed of the testing heads of the machines was 0.05 in. per minute, generally adopted as standard, and the requirement of A. S. T. M. specification C39-25. These latter machines are equipped, in accordance with the foregoing specification, with a spherical bearing block for the top of the specimen.

The results obtained are tabulated below. Although not shown in the table, the rate of deformation is very slow at first, then increases in value, becoming practically constant and remaining so throughout the greater part of the test. This latter rate has been given in the table. Although it is to be expected that the rate of deformation of the concrete will be less than the speed of the head when the cylinder is capped on both ends with plaster of Paris, the large difference in speeds is surprising, moreover, in view of the difference in speeds being maintained through the greater part of the test. The speed difference of head and rate of deformation of the concrete cylinder without caps is even more unexpected.

Rate of Deformation and Testing Machine Head Speeds

Capacity of machine (in pounds)	Cylinder diameter In.	Speed of testing machine head In. min.	Rate of compression of specimen In. ft. min.
600,000	18	[1]0.050	[2]0.0019
			[3].0021
	12	[1].050	[2].0028
			[3].0035
		[1].055	.....
		.038	[3].0038
	6	.044	[3].0036
200,000		.018	[3].0061
		.021	[3].0074
		.022	[3].0070

[1]Idle speeds.
[2]Specimens capped with plaster of Paris on both ends.
[3]No caps; cylinder ground on both ends.

New Hoist Mechanism Gives 60° Dumping Angle

The Autocar Co., truck manufacturers of Ardmore, Pa., has just perfected a new rotary dump hoist mechanism which it is stated will raise the body to an angle of 60 deg.

The Autocar rotary dump mechanism is one of the oldest power dumping

Autocar With New Rotary Dump Hoist Mechanism

mechanisms on the market. It was developed by the Autocar Co. in the early days of the motor truck industry in response to a demand for a method by which the power of the engine would be used to elevate the dumping body instead of hand power dumping with a crank.

One of the most important features of this new mechanism is the automatic cut-out which, as the name implies, cuts off application of the power just as soon as the body reaches the maximum elevation and similarly cuts off the power when the body has returned to full normal position. This requires no attention from the driver of the truck and he may put the truck in motion before the body has returned to normal.

The new 60-deg. dumping angle will greatly increase the ease with which a wet-batch may be dumped and it is chiefly for the highway and construction trade that Autocar perfected this new mechanism.

The Value of An Adequate Materials Department

A Paper Presented at 17th Annual Wisconsin Road School

By C. R. STOKES
Materials Engineer, Wisconsin Highway Commission

PROBABLY there is no state in the Union as plentifully endowed with road materials as is our own. We are indeed fortunate that this is the case for the construction and maintenance of our highways, to satisfy the present-day needs of traffic, necessitates the use of immense quantities of materials. Highways have been constructed and surfaced in Wisconsin with all the various materials to be found in the state. We have used the gravels, the limestones, the granites, the shales, etc. The expenditure involved in constructing and maintaining our present large road mileage has been tremendous, and still at the same time we can point with pride to the fact that we have utilized our natural resources, and by so doing have saved the taxpayers of this state many dollars.

The Need For Special Study.—But have we managed to utilize these same resources to the fullest extent possible? In other words, has our consideration of the subject of road materials in its entirety been extensive enough to warrant an affirmative answer to this question? It is doubtful whether an affirmative answer would be justified at this time. Rather than say we are satisfied with what has been done, we can still accomplish a great deal more by making a special study of the subject of road materials, realizing the potential possibilities involved, and by so doing gain a great deal more than we already have. The assistance of all should be enlisted in such an enterprise and a department specializing in a study of road materials and their adaptability to the construction and maintenance field, can be of very valuable service.

Contrary to common belief in some quarters, by the term Materials Department, it is not meant to infer that this applies only to the laboratory at Madison. Naturally the laboratory is a very important part of the department. It is the only place where we are able to determine certain facts concerning materials. It is the one place where we are able to ascertain whether or not various materials used in our highway building should be accepted or rejected as unsuitable. It is of valuable assistance to us in writing our specifications. We use the laboratory extensively when attempting to solve problems directly concerned with research. In other words it is a most important cog in the wheel but not by any means the only one.

The Division Materials Engineer.—It is in the field where the real important work concerning road materials is necessary. For this reason there has been established in each division office the position of Division Materials Engineer. The man holding this position is a very important part of the department, for he not only will be the contact between the field activities and the laboratory but he will be the representative for the department in the field. He will be in close touch with materials in his division and will be in a position to obtain the cooperation which is so vitally necessary in securing the maximum of service from the department. That such cooperation is most important is indisputable. Every public highway official is interested in ways and means of building better highways and in reducing the cost wherever possible. There is no better way to accomplish these things than by a careful selection and use of road materials. But this cannot be left alone to the judgment of one or a few men—it demands the concerted thought and ideas of all.

At first thought it might seem to some that there is hardly enough work on materials in a division to justify one man putting in his entire time at it. However, this is far from the case, for if he properly develops the job and makes the most of his opportunities he will have as much or more than he can handle to do. His work, if properly done, will make him not only of great value to the Materials Department but to the county highway organization and his own office as well. He is also in a very advantageous position to act as salesman in putting across the ideas in regard to materials and materials savings to the public. This is pertinent, for the public, especially taxpayers, are beginning to realize that every dollar paid for unnecessary transportation of materials either by rail or truck increases the cost per mile and shortens the total mileage that can be built with the funds available. An efficient division materials engineer is a tremendously important factor in the organization of an adequate Materials Department and his work and cooperation with the counties will serve to greatly strengthen that department and make its services that much more valuable to every one.

Road Material Surveys by Geologists.—One of the most important functions of the Materials Department is the proper investigation of road materials for use in highway construction. With but few exceptions, it is necessary for a road material survey to be conducted by competent geologists trained in this work. Given the time and opportunity the county highway official or the engineer can make a search for local material. However in the search for undeveloped deposits of materials a considerable knowledge of the local geology is very desirable, since most deposits of this nature are hidden by a layer of soil. Unless the searcher knows where these deposits are likely to occur much of his effort is very liable to be wasted. Therefore men trained in geology are best qualified to carry on such a survey for they know the various rock formations and are thus able to eliminate large areas from consideration, and to concentrate upon the more favorable ones. Whereas the geologist can give all his time and energy to the job the county highway official is often too busy to spare the time necessary for this work.

But when such a geological field party is working in his division, the division materials engineer should arrange to spend as much time as possible with them. If he does this he will be able to acquaint himself with their methods and also obtain valuable training in the geology of the country. Inasmuch as he has direct charge of the follow-up work, namely, the test pitting of the locations recommended by the survey party, he will have had a chance to familiarize himself with these locations and can better formulate his plan of procedure. If he has spent considerable time with the material survey party and has his test pitting crew well organized, he can often step in and start the test pitting operations, without waiting for the survey reports to reach him in their final form. If this were done a lot of time could be saved, and the work could proceed under much better conditions than if it was left until late in the fall to do.

Importance of Thorough Test Pitting.—Too much stress can hardly be placed on the idea of adequate preparation, which can be summed up in two words, thorough test pitting. Mistakes are costly and must be avoided and they can be avoided by careful work. There

is but one exploration method which will prove practical if accurate determinations are sought open to the materials engineer and that is to have his test pitting crew dig into or through the deposit at various points so that definite conclusions may be drawn as to the quality and extent of the material and depth and character of the stripping. A thorough follow-up of the material survey precludes expense, for in most instances such expense will be found insignificant when compared with the savings which may be effected through use of the investigated material site. And even if it is found that the particular site proves undesirable for the immediate project in question, it may be useful for surfacing and maintenance later on.

Whereas the principal saving effected by a careful investigation and selection of road material sites is in transportation costs, often times it is possible to effect quite a saving by changing the type of surfacing originally contemplated and using the material available.

Importance of Definite Material Information.—Such an instance as this occurred a few years ago when an investigation was conducted for concrete paving aggregate on a particular project. This investigation showed that concrete could be built only at an excessive cost, but that materials suitable for a wearing surface were available. Accordingly the plans were changed and about six miles of entirely satisfactory road was built at the cost of 3.5 miles of concrete as originally planned. These are particular problems for the Materials Department and especially the division materials engineer. Nor is the solving of them exceedingly difficult, provided he is fully familiar with the topography and geology of the section.

The same knowledge of the country in regard to materials is applicable to maintenance as well as construction, for it is equally important that we effect a saving if possible in this phase of the work. One particular instance is recalled to mind where a certain county was dead hauling very mediocre gravel four miles to one end of a three-mile gang maintenance gravel surfacing project. The gravel being used was so poor that the three miles were surfaced and resurfaced three time in rather rapid succession, before an efficient material investigation disclosed an undeveloped deposit of excellent gravel almost in the center of the job and with approximately a quarter of a mile dead haul.

Imagine the chagrin of all concerned over the realization of the money wasted on haul in this particular case. This is a rather prevalent condition in some parts of the state and could be averted by careful work by the division materials engineer. With the exception of those maintenance sections comprised of concrete roads he should make a thorough study of and be thoroughly familiar with the materials adjacent to every maintenance section in his division. This looks like a large undertaking, and it is, but if a few such cases as have just been mentioned can be avoided he will have been more than repaid for his efforts. In doing this work he should keep in close touch with the county road officials, as he will often time be able to act in an advisory capacity to them. Furthermore his knowledge obtained from such a study could be valuably employed by the division engineer in planning his future construction projects. With definite material information to refer to he would be able to plan his future work on a far more efficient scale.

Determination of Rock Cut Quantities.—A service which an adequate Materials Department should develop is that of assisting in the much muted question of rock classification or perhaps, to put it more clearly, in aiding in the determination of the amount of rock to be encountered in deep cuts. The engineer making the road survey estimates these quantities to the best of his ability, but obviously his estimate must of necessity be more or less of a guess. A neighboring state has solved this problem to a large extent by using a drilling outfit to put in a series of holes and thus obtain a pretty clear idea of the cross section of the rock cut. Such a plan should be developed in Wisconsin for undoubtedly considerable savings could be effected on rock prices and a great deal of unwelcome controversy avoided.

Studies of Gravel Deposits.—There is room for a careful study of the quality of the materials used in surfacing our roads. While this is true for shales, granites, etc., perhaps in no lesser degree it is particularly true of gravel. To a great many, gravel is gravel, but it is really surprising to note the difference in gravels. For example, some gravels with apparently little binder content will set up rapidly while others containing quite a bit of clay remain loose on the road. We know there must be a reason, but it will take time and careful study to work out the answer. The materials engineer should also study the various sizes of gravel encountered in different deposits. As it is required to crush gravel to 1 in. for gravel surfacing, it can readily be seen that the finished product of a screening and crushing plant set up in a pit abounding in very coarse particles will be radically different from that produced in a deposit consisting largely of very fine material. Which will eventually produce the easier maintained and longer lived surface? A problem for the materials engineer and one requiring considerable study to be made of many roads under actual traffic conditions. These are very interesting problems and apply to other surfacing materials as well as gravel. There are ways to solve them in a purely scientific manner.

Preventing Lawsuits in Development of Local Deposit.—In connection with developing a local deposit perhaps little thought has ever been given to the possibilities of lawsuits, because of a contractor operating a questionable pit or quarry. Of course, we'll say, if the follow-up work is done thoroughly there should be little chance of failure. This is true, but on the other hand there are local deposit operators, who possibly through their own inability or negligence have failed in their pit or quarry operations and are anxious to cast off the responsibility and attach the blame elsewhere. Such a case might easily be brought into the courts, and if so is the state or county going to be in a position to contest it? The answer is, what kind of record has been kept of the deposit in question? Were pictures taken during its operation? Were the methods of operation such as to insure the most successful production? It can readily be seen that a complete check up and a written record would forestall the filing of a suit or at least be wonderful defense ammunition. The division materials engineer should have a complete record of every deposit both large and small operated in his division. I can recall at least one instance where information of this sort in complete form would have saved the county a considerable sum, for such a suit was made and settled only when the county agreed to pay a certain amount of money. Unfortunately no complete record of the operation had been kept in this case.

Purchasing Deposit Site.—In connection with the development and use of material deposits, the division materials engineer can extend valuable help and service in the matter of assisting county officials in obtaining options or purchasing deposit sites from the owners. This is a matter which requires a lot of thought and the exercising of good judgment. An option on a given road material deposit should be obtained at the time of test pitting or preferably even before test holes are put down, for it is better to have a working agreement with the owner. A legal option form should be used and the royalty or agreed price which the owner is to receive for the road material should be specifically stated therein. This matter of royalty presents quite a problem and the division materials engineers' knowledge of the country should be of much assistance in solving it. Supply and demand should naturally determine the royalty.

In the past it has been easy to follow the path of least resistance and use road material from a known source, paying a price per yard determined by custom, thereby ignoring supply and demand to a large extent. This custom originated in the old days when the road district purchased but a few hundred yards of road material per year and paid for them by the load. On this scale of purchase 10 or 15 cents per load but little more than paid the owner

for his trouble. At the present time, when thousands of yards are used on a single job, this old custom has resulted in an extravagant notion of what road material is really worth.

Purchasing Gravel by Cubic Yard and Acre Basis.—There is also an unfortunate local sentiment in some localities that since it is a public expenditure, the owner is justified in "soaking the county." As a result of all this, many owners have become imbued with the idea that they have a monopoly and large and unreasonable royalty prices have been paid in many cases. That this is true was determined from a compilation of figures a year or two ago, when reports on prices paid for gravel were requested and received from 57 different counties. Purchased on the cubic yard basis, the minimum cost per cubic yard was 2:5 cts., the maximum 51 cts. and the average 15.4 cts., or computed on an acreage basis an average of $3,199 per acre. Compare these figures with those where road material was purchased by the acre at a minimum cost of 8/100 ct. per cubic yard, a maximum cost of 5.9 cts. per cubic yard, an averave cost of 1.71 cts. per cubic yard and an average cost per acre of $311 as against $3,199. This simply means that in the figures given, seven to fifty times the agricultural land value was paid for road material when purchased by the cubic yard.

It is impossible to estimate what this method of purchase has cost the state, but it has probably increased the cost of construction in nearly every town and county in the state. If in a few areas where road material is scarce these unreasonable prices were paid, there might be some justification for the custom. The trouble is though, that the same price has been paid for road materials in counties where it is abundant as in counties where it is scarce. In many cases much higher royalty is being paid for road materials than is being paid for iron ore which is relatively uncommon and the total tonnage insignificant as compared to the supply of road materials.

Let us carefully consider these facts when negotiationg for the purchase of road material. It would undoubtedly be foolish to try and lay down a hard and fast rule that all road materials should be purchased on an acreage basis. I know of several instances this past season where the division materials engineer helped to obtain options on road materials on a cubic yard basis, at a price probably as cheap as on an acreage scale. Still the supply and demand and the value of agricultural land should constanty be borne in mind when such purchases are being made, and it will be found that in the end, in most instances, that the purchase of materials on the acreage basis will be the better and less expensive way.

The Value of Research.—It is doubtful whether anyone closely connected with the building and maintaining of highways can dispute the value of research. Since starting in this business, we have all seen so many new developments, the direct result of research, that we would indeed be blind if we were not already convinced of its real value. With our own limited facilities we have done enough of this type of work to make us realize its great importance. One of the outstanding pieces of work in this respect which comes to my mind was our investigation, a few years ago, of the so-called "northern gravels."

I say northern so-called because that has been the term commonly used to designate the gravels in question in comparison with those to be found in the extreme eastern and southern part of the state. Whereas these latter gravels are mostly dolomitic or limestone in composition the northern gravels, found in Wisconsin's central and northern counties, are igneous and represent the remains of some of the earth's oldest rocks.

The individual pebbles are nearly all smooth surfaced, well rounded, non-absorptive and have a high degree of hardness. It was these characteristics of this type of material, which was causing the trouble and which resulted in a research study being made of them. In other words we had found in the field first, that our concrete roads were cracking badly, when these materials graded from ¼ in. to the usual 2 or 2½ in. size were used in 1:2:4 proportions. In the laboratory we found support for these conditions in that our 1:2:4 test specimens of these materials were showing very low transverse strengths. At first we tried richer mixes, eventually finding that a 1:1½:3 proportion gave sufficient strength and this mix was recommended for field work. Technically and practically perhaps such a proportion was satisfactory, but as an economical proposition it was hardly feasible.

The great difference in cement content between the two proportions scarcely justified even the use of these materials, but when we considered the future programs for this section of the state we were appalled to think that we either must consider materials from distant sources or use an exorbitant cement factor. Somehow, it seemed to us, there must be a way to solve this question, though we had to admit we were sorely quzzled. We even consulted some of the best known authorities on concrete design and materials, and were informed that our first plan of trying richer mixes was about the best we could hope to accomplish.

But we still thought something could be done, so we shipped some 20 tons of these materials representative of the material of several different commercial pits into the laboratory and commenced our study. We found that we could still use lean mixes with these materials and also develop satisfactory strengths by merely crushing these gravels to a smaller maximum size. By doing this we produced many more fractured pieces, and consequently more rough edges and surfaces for mortar to adhere to, and immediately the problem of bonding strength was solved. A simple thing and still one requiring experiment and study. And the results made the expense of the study truly insignificant, for many dollars have been saved and many still will be through just the difference in cement content between the rich mixtures formerly tried and the leaner ones now used.

Elimination of Grade Crossing Hazards

The elimination of grade crossing hazards is urged in a brief filed with the Interstate Commerce Commission by the American Motorists' Association in connection with the Commission's hearings on the adequacy of automatic train control. The motoring association urged that there is greater need, at the present time, for safety at grade crossings than there is for automatic block signals or train control devices. Many representatives of the leading railroads have likewise urged upon the commission the necessity for the elimination of the grade crossing hazard.

The grade crossing problem is far more pressing at this time than block signals for automatic train control, both the association and a majority of the railroads have informed the commission. Figures presented to the commission by the motoring association showed that during January, the latest figures available, no railroad passenger was killed in a railroad accident. During the same month, 471 highway grade crossing accidents were reported, with a total of 185 deaths and 529 injuries, of which approximately 80 per cent were automobile-train accidents, the Association's figures show. In January of last year, the railroads reported 499 accidents, resulting in 206 deaths and 604 injuries.

"The enormous increase in motor traffic and the increase of accidents at road crossings have resulted in a major problem to the motorists and the railroads," J. Borton Weeks, president of the Association declares. "The elimination of grade crossings is far more urgent than automatic control of trains. Figures of the commission show that from 10 to 20 times more fatalities occur at grade crossings than occur as the result of lack of automatic control." The Association cited figures showing that in recent years the bulk of all accidents have been at grade crossings. As a fair example, figures of a mid-western line, operating 900 miles of track, are cited, showing that it had but six fatalities in connection with train operations during the past three years, while during the same period, 77 persons were killed at grade crossings on the same line.

Power Shovel Operation in Highway Grading

Factors Affecting the Operating Cycle of the Shovel

By T. WARREN ALLEN and ANDREW P. ANDERSON
Chief Division of Management; and Associate Highway Engineer, U. S. Bureau of Public Roads

THE operating cycle of the power shovel consists of the consecutive actions of (1) loading the dipper, (2) swinging it over the wagon or other hauling unit, (3) dumping it, and (4) swinging it back to loading position. From time to time the shovel must also be moved forward so as to keep within easy digging reach of the face of the cut. This, however, is not a part of the regular operation cycle, but rather a necessary interruption, the relative frequency of which varies principally with the depth of the cut.

Efficiency in power-shovel operation is dependent on the operator and on the shovel itself. A first-class operator may be able to secure fair production with an old or a second-rate shovel, but a poor operator is a heavy handicap even with the very best equipment. It is hoped the records of performance which this series of papers contains may help constructors to increase their present rates of shovel production and the power-shovel manufacturers to so perfect their shovels as to meet still better those conditions which are prerequisite to high rates of production.

How Operating Cycle Affects Output.—It has been stated that under ordinary field conditions the fastest obtainable operating cycle in good common excavation is in the neighborhood of 15 seconds when the swing is 90 deg. The importance of approaching this limit as closely as possible can hardly be overstated. A 15-second cycle consistently maintained will yield the large output of 240 dipper loads an hour. To attain a 15-second cycle it is necessary to load the dipper regularly in 4 to 5 seconds, to swing it over the wagon in 4 to 5 seconds, to dump it in 1 to 1½ seconds, and return it again to loading position in 4 to 5 seconds. Lengthening the cycle time to 20 seconds drops the output to 180 dipper loads an hour—a reduction of 25 per cent. If the cycle is lengthened to 25 seconds, the best the shovel can turn out is 144 dipper loads an hour, while if a 30-second cycle obtains the output can not exceed 120 dipper loads.

The difference between operation on, let us say, a 15-second cycle and on a 20-second cycle is often a matter of a second or so in loading, a slight hesitation during the swing, with perhaps a bit of delay in spotting over the wagon—delays which may not be noticed except with the aid of extended stop-watch readings. It is not surprising to find that slow operators are sometimes rated as fast because the contractor has nothing definite with which to compare their work and to find that fast operators are sometimes being discredited because job conditions or methods of job management over which they have no control hold down the output.

Data collected by the Division of Management of the U. S. Bureau of Public Roads in its studies of power shovel operation in highway grading, indicate that there were few jobs on which a material increase in output cannot be obtained without a corresponding increase in cost. In some cases it was found possible to increase output as much as 100 per cent by a change in management methods. The results of these studies by the Division of Management have been set forth by Messrs. Allen and Anderson in Public Roads, the official publication of the U. S. Bureau of Public Roads. Some of the more general requirements necessary for efficient, economical power shovel production, as developed by the studies, were given in our April issue. In this issue we are printing that portion of the article relating to the factors affecting the operating cycle of the shovel.

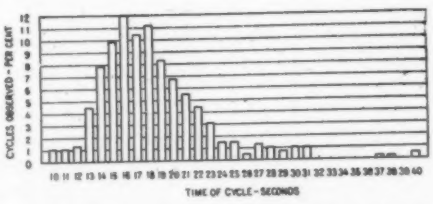


Fig. 1.—Diagram Showing Percentage of Shovel Cycles Performed in Various Time Intervals. Based on 383 Complete Cycles (4 Greater Than 40 Seconds) of a ¾-Yard Shovel Working in an 8½ Ft. Cut of Blasted Shale and Loading Trucks at Side. Average Time per Cycle, 18.9 Seconds

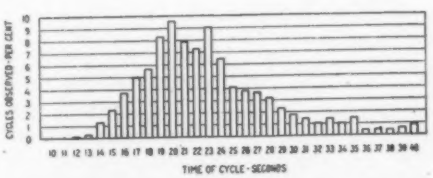


Fig. 2.—Diagram Showing Percentage of Shovel Cycles Performed in Various Time Intervals. Based on 1,058 Complete Cycles (43 Were Over 40 Seconds and Not Shown) of a ¾-Yd. Shovel Working in 1 to 5 Ft. of a Sticky Clay and with an Angle of Swing of from 45 Deg. to 90 Deg. Average Time per Cycle, 23.9 Seconds

Examples of the full operating-cycle time where loading was at the side of the shovel are shown in Figs. 1 to 5. A detailed analysis of each of the four parts of the operating cycle seems advisable in order to establish more clearly the parts played, respectively, by the operator, the machine, and the material in determining and controlling the rate of production. This will be followed by a somewhat similar analysis of the additional factors affecting production which are more or less completely under the control of the management.

The first activity of the operating cycle is loading the dipper and its effectiveness is dependent on the size of the load and the time taken in securing it. To sacrifice, say, 10 per cent of the size of the dipper load in order to increase the number of dippers by 10 per cent results in a loss in material dug and smaller loads for the hauling units. The smaller the time of loading the dipper as compared with the time of the entire cycle, the greater is the importance of securing a full dipper. It is more important to try for a full dipper when the swing is long than when it is short. In very shallow cuts a low boom will aid in securing a fuller dipper, as will a high boom in a deep cut.

Dipper Loads and Quantity of Material Moved.—In making these studies determinations have been made as to the number of dipper loads and quantity of material moved under various conditions. Quantities were determined from careful cross-sectioning and are thought to be large enough to represent average conditions. Table I gives the results obtained on several jobs. For a so-called ¾ yd. bucket having a capacity of approximately ¾ cu. yd. when struck horizontally in line with the top of the teeth and the top of rear edge, the average dipper load may vary from 0.3 to 0.8 cu. yd., depending on the material and the skill of the operator. In fair to good common reasonably free from roots and bowlders, a good operator working under favorable conditions should dig an average of 0.5 or 0.6 cu. yd. per dipper load. In poorly blasted rock or shale, very rooty and stumpy soils, and certain tough, moist clays, the average load may be only 0.35 cu. yd. or even less in exceptional cases. In shallow cuts the average load is likely to be low. Materials

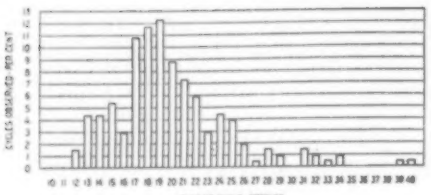


Fig. 3.—Diagram Showing Percentage of Shovel Cycles Performed in Various Time Intervals. Based on 204 Complete Cycles (5 Were Over 40 Seconds and Not Shown) of a ¾-Yd. Shovel Working in from 8 In. to 2 Ft. of Loamy Clay with an Angle of Swing of from 45 Deg. to 90 Deg. Average Time per Cycle, 20 Seconds

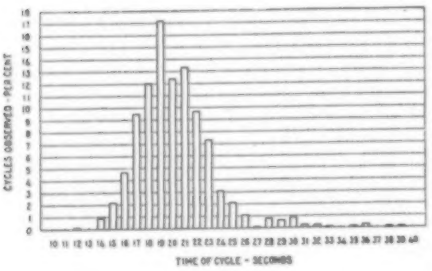


Fig. 4.—Diagram Showing Percentage of Shovel Cycles Performed in Various Time Intervals. Based on 734 Complete Cycles (3 Were Over 40 Seconds and Not Shown) of a 1⅛-Yd. Shovel Working in 2 to 6 Ft. of Clay with a Few Bowlders. Length of Swing, 45 Deg. to 90 Deg. Average Time per Cycle, 20.3 Seconds

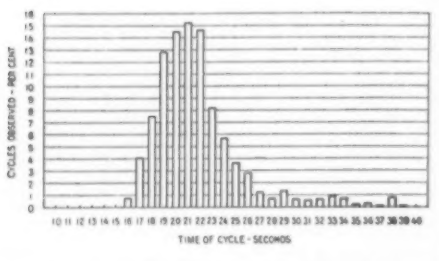


Fig. 5.—Diagram Showing Percentage of Shovel Cycles Performed in Various Time Intervals. Based on 1,322 Complete Cycles (20 Were Over 40 Seconds and Not Shown) of a 1⅛-Yd. Shovel Working in from 1 to 6 Ft. of Clay with a Few Bowlders with a Swing of from 40 Deg. to 90 Deg. Average Time per Cycle, 22 Seconds

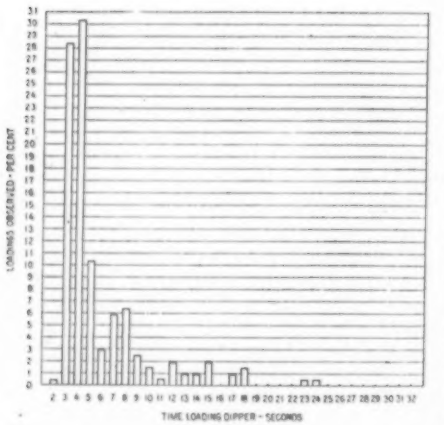


Fig. 6.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 204 Loadings of a ¾-Yd. Dipper (3 Were Over 32 Seconds) in a 1½ to 2 Ft. Cut of Loamy Clay. Average Time, 6.1 Seconds

Table I.—Number of Dipper Loads and Quantity of Material Moved Under Various Conditions.

Type of shovel	Capacity	Character of material	Quantity moved	Dipper loads	Average loading
	Cu. yds.		*Cu. yds.*	*Number*	*Cu. yds.*
Steam	¾	Light moist clay, free from roots and stones	57	147	0.39
Do.	¾	do	114	223	.51
Do.	¾	do	85	170	.50
Do.	¾	Light moist clay, with some shale	65	148	.44
Do.	¾	Loamy clay, with 25 per cent loose rock	19	50	.38
Do.	¾	do	63	176	.40
Do.	¾	Sand-clay	49	82	.60
Do.	¾	do	93	150	.62
Do.	¾	Loamy to hard clay	49	85	.58
Do.	¾	Loamy to sandy clay	50	141	.35
Do.	¾	Loamy to clay	60	157	.38
Do.	¾	do	39	72	.53
Do.	¾	Gneiss-granite, poorly blasted	965		.53
Do.	¾	Wet sticky clay, with a few stumps	1,167	1,745	.67
Do.	¾	Moist to wet sand-clay	1,408	1,825	.80
Do.	¾	Sandstone, well blasted	219	632	.35
Do.	¾	do	1,120	2,598	.43
Do.	¾	Moist clay, with a few small surface bowlders	518	794	.65
Do.	¾	Very wet clay	588	990	.59
Do.	¾	Wet clay, with small stumps	100	210	.48
Do.	¾	Sandy gravel, with some hard chunks of shale	1,683	4,099	.41
Do.	¾	Dry loamy clay	162	309	.53
Do.	¾	do	29	71	.41
Do.	¾	Granite-gneiss, poorly blasted	1,335		.40
Gas	¾	Loamy clay, moist, with a few roots	356	563	.63
Do.	1⅛	Sandstone, blasted	1,840	3,448	.53
Do.	1⅛	Dry clay, with a few bowlders	1,523	2,862	.53
Do.	1⅛	Dry clay, with surface bowlders	635	986	.64
Do.	1⅛	70 per cent large bowlders and 30 per cent dry clay	394	687	.57
Do.	1⅛	10 per cent dry clay, 20 per cent loose rock, 70 per cent solid rock, blasted	2,730	4,391	.62
Do.	1⅛	Wet sticky clay, with a few surface bowlders	1,304	2,398	.57
Do.	1⅛	20 per cent dry clay, with 80 per cent sandstone, well blasted	474	794	.60
Steam	¾	Sandy clay and clay loam, with some stone	1,515	3,304	.44
Jas	¾	10 per cent sandstone, poorly blasted with 20 per cent clay	393	798	.45
Do.	¾	do	3,010	6,646	.46

which bulk considerably when broken up or which lack cohesion, and will not heap up on the dipper, are apt to show a low average yield per dipper load.

In general, the largest average dipper load can be secured from cuts of moderate depth, from 5 to 7 ft. being perhaps the most advantageous in materials not needing to be blasted. The size of the dipper load is sometimes affected by the position in which the hauling units are loaded. In loose, friable materials which spill readily, a long swing and especially loading near the limiting height to which the shovel can reach is certain to reduce the amount of material moved per dipper load. Since the rate of operation in materials of this kind should be around 200 dippers an hour, even small differences in the size of the dipper load become important.

Three cases were studied where the contractors in a laudable effort to secure a large yardage per dipper load has replaced regular ¾-yd. dippers with 1¼-yd. dippers. This proved a decided handicap, except possibly in extremely soft and easy digging, as the power was insufficient to force the large dipper into the material. Not only was the production less than the normal for a regular ¾-cu. yd. shovel, but time losses due to breakage and repairs were high. This seems to indicate that for general highway work increased production is not to be had by increasing the size of the dipper above that for which the shovel is designed.

The time required to load the dipper often varies considerably from the average, as shown in Figs. 6 to 12 and Tables II to IV. Each of the graphs shown covers a number of observations and shows the number of times the dipper was loaded in any given number of seconds. They show that a few of the loading times took very much longer than the others and reduced the average very materially.

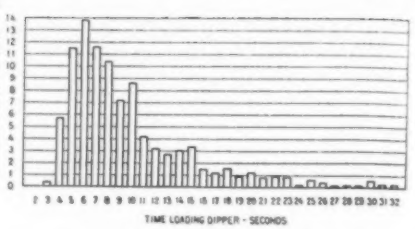


Fig. 7.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 1,058 Loadings (18 Were Over 32 Seconds) of a ¾-Yd. Dipper Working in 1 to 5 Ft. of Sticky Clay. Average Time, 10.29 Seconds

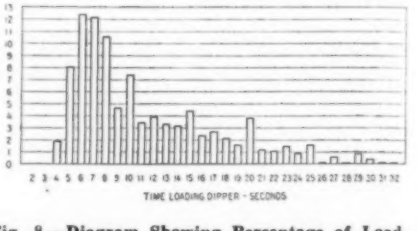


Fig. 8.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 658 Loadings (16 Were Over 32 Seconds) of a ¾-Yd. Shovel Working in 2 to 6 Ft. of Sticky Clay. Average Time, 12.2 Seconds

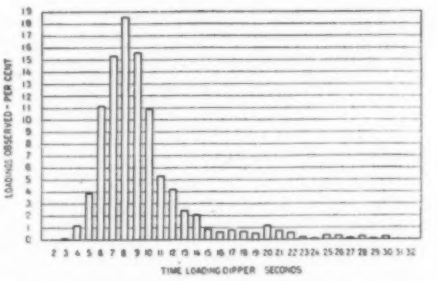


Fig. 9.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 1,322 Loadings (15 Were Over 32 Seconds) of a 1⅛-Yd. Dipper Working in 1½ to 5 Ft. of Clay and Loam With a Few Bowlders. Average Time, 9.67 Seconds.

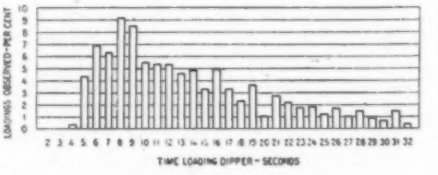


Fig. 10.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 763 Loadings (21 Were Over 32 Seconds) of a ¾-Yd. Dipper Working in 1 to 4½ Ft. of Light Loam. Average Time, 16.5 Seconds

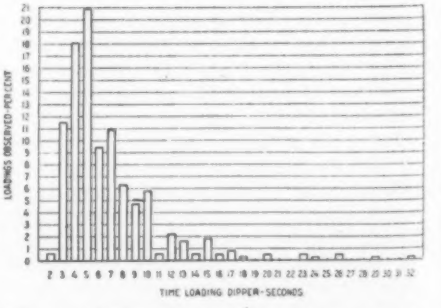


Fig. 11.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 383 Loadings (6 Were Over 32 Seconds) of a ¾-Yd. Dipper Working in an 8 to 9 Ft. Cut of Blasted Shale. Average Time, 6.9 Seconds

Figure 6 shows a job in loamy clay where the performance was excellent. A comparatively large number of dipper loads were secured in four seconds. The average loading time was 6.1 seconds, and there were only a relatively small number of dipper loads which took a long time to secure—an indication that a good, consistent operator was handling the shovel. The average time during this study for the full cycle of loading, dumping, and return, however, was 20 seconds, since the swing was rather long and the material sufficiently moist to hang somewhat in the dipper.

Job Conditions Determine Whether More Than One Pass of Dipper Is Justified.—Special attention is drawn to Figs. 9 and 11 as examples of good, consistent operation. In the case shown in Fig. 8, work was in somewhat sticky clay in which it was hard to secure a full load. In about 50 per cent of the cases observed, one lift of the dipper was used to secure a load, and in these cases the dipper load was secured in an average of less than seven seconds. In the remaining cases, two or three or even four passes were made to fill the dipper to the satisfaction of the shovel runner. The result was an occasional extension of the time required in filling the dipper to as much as a full minute. The average time for all of the studies was 12.2 seconds. Figs. 6, 9, and 12 show the results where the operator regularly made only one pass with the shovel, loading whatever he was able to secure. In these figures are noted the small number of very long readings, and such as occurred were due principally to stumps or heavy rocks.

Table II shows the time required in making two or more passes to load the dipper where the shovel was operating in ordinary gravelly clay in moist to wet condition. The average time for loading the dipper when only one pass was necessary was 7.2 seconds. When two passes were required the time rose to 14.1 seconds and to 21.2 seconds for three passes. Thus, each additional pass increased the time required to load the dipper by 95 per cent above the time required where only one pass was necessary.

But production is the product of the number of dipper loads and the average quantity per dipper load. Consequently, the value of making additional passes is dependent on the amount of material which such passes will add to the dipper load and the speed at which the shovel is operating. If a ¾-yd. shovel is operating in fairly good common in which the average dipper load is about 0.5 cu. yd. of material as measured in place, and the average operating cycle is 20 seconds, then production is at an average rate of 0.025 cu. yd. per second. If a second pass to fill an occasional dipper is to be profitable, it must serve to increase the dipper load at least at this rate, for the time required to make the extra pass. Thus, if six seconds are required to make an extra pass under the above conditions, it would not be warranted unless at least 0.15 cu. yd. could be added to the load. In other words, whenever the first pass secured as much as three-fourths of an average dipper load a second pass would not be warranted, considering the case from the viewpoint of shovel output alone.

Not Possible to Formulate Definite Rules of Procedure.—Definite rules can not be formulated since each operation is interrelated with many other possible conditions surrounding the entire job. It is possible to show the principles which apply and by means of which the proper procedure can be determined. It has been stated that the importance of securing a full dipper load is greatest when the time required to load the dipper is in smallest ratio to the total shovel cycle, and vice versa. Therefore, more attention to securing a larger dipper load is justified when loading at the rear of the shovel than when the loading is at the side. In shallow cuts, where much skimming is required, dipper loads are almost certain to average a low quantity. Keeping the boom lower than normal will generally help in securing larger loads. On such work a considerable amount of time is consumed in moving the shovel. If there is any considerable amount of it, the contractor may well consider the advisability of using some other method on such portion of the work.

It is not possible to state categorically that any one system of operation is always to be preferred. In the case illustrated by Fig. 8 the swing was long and there was not enough hauling equipment on the job; so lengthening the dipper cycle in order to secure a full dipper load did not, in fact, subtract much from the shovel output, while it tended to insure a full wagon-load every trip which increased the job output. In the cases shown in Figs. 9 and 12 the shovel was a 1⅛-yd. machine and two full dippers overloaded the wagons. As long as the operator could get one full dipper load out of two, he could send the wagons to the dump well loaded without making multiple passes. On this job the wagon

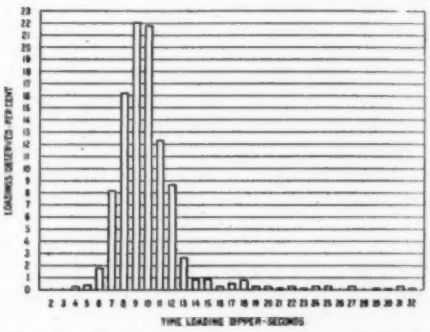
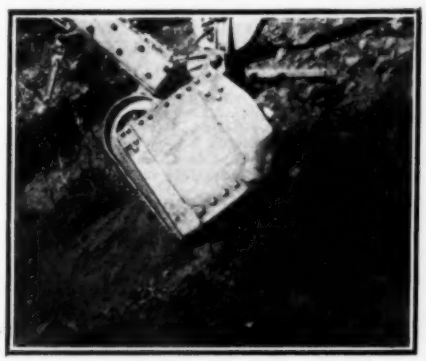


Fig. 12.—Diagram Showing Percentage of Loading Operations Performed in Various Time Intervals. Based on 734 Loadings of 1⅛-Yd. Shovel Working in 2½ to 7 Ft. of Clay With a Few Bowlders

Table II.—Time Required in Making Multiple Passes in Loading Dipper in a Moist to Wet Gravelly Clay

Number of passes	Number of observations	Average time per dipper load
		Seconds
1	1,322	7.2
2	298	14.1
3	92	21.2
4	32	27.6
Total or average	1,744	9.4



Loose, Dry Material Falling from Top of Dipper

Light Work Where More Than the Average Amount of Time Is Required to Fill Dipper

supply, generally speaking, was above average so that fast operation was desirable.

But, aside from the conditions prevailing on these two jobs and the rates attained, these two figures show several of the general characteristics of what, under normal working conditions, would be good operation and poor operation. A good operator working in anything like good material under favorable conditions of depth and face of cut obtains a loading diagram for his dipper like those in Figs. 6, 9, and 12. A poor operator always has an operating record more or less like those in Figs. 8 and 10. On the jobs represented by the first set of graphs the shovel was so handled that the desired load was obtained quickly with one pass of the shovel. On the jobs represented by the second set the rate was slower, and frequently two, three, or more passes were made to fill the shovel.

Table III.—Effect of Material on Time Required to Load a ¾-Yd. Dipper as Indicated by One-Hour Stop-Watch Studies with Same Operator Throughout on Each Shovel

SHOVEL NO. 1

Kind and character of material	Time to load dipper	Height face
	Seconds	Feet
Light sandy loam, free from roots and stones	3.3	10.0
Do	3.7	7.0
Loamy clay, free from roots and stones	4.5	6.5
Do	4.7	8.0
Do	4.8	10.0
Do	4.9	2.0
Light clay and loam top soil, no roots or stones	5.0	5.0
Light clay with small amount of soft shale	5.0	5.0
Loam	5.1	7.0
Light clay, free from roots and stones	5.6	10.0
Light clay with small amount of shale	5.7	10.0
Do	5.9	6.0
Light clay with increasing amount of shale	5.9	7.0
Loamy clay, with some roots	6.0	6.5
Ordinary clay, free from roots and stones	6.3	4.5
Loamy clay	6.5	6.5–11.5
Light clay and soft shale	6.6	8.0
Loamy clay with loose rock in old roadbed	6.3	2.0
Clay with 30 per cent loose shale	6.7	9.0
Hard clay with loose rock in old roadbed	10.9	9.25–11.5
Hard clay with loose rock	10.3	3.0

SHOVEL NO. 2

Light, loamy clay, no stones or roots	5.3	5.5
Do	5.3	4.0
Light clay, free from stones or roots	5.7	4.0
Light clay, practically free from roots and stones	6.0	5.5
Light clay with old hard roadbed on one side	6.7	6.0
Do	6.9	4.0
Light to medium clay	7.3	6.5
Clay and soft shale	8.3	3.0
Light clay with small amount of rock, side hill cut	8.2	0–4.0
Clay and soft shale	9.4	7.0
Sandstone, soft enough to crumble in hand	11.0	11.0

Table IV.—Time Required to Load Dipper in Various Kinds of Material. Each Entry Shows the Number of One-Hour Studies in Which the Average Time of Loading Fell Within the Range Indicated. Studies Were Made on a Great Many Typical Jobs

Average time to load dipper (seconds)	Loam, loamy sandy, gravelly clay, or clay, free from rocks, practically free from roots, boulders, etc.	Ordinary clay, loam, ordinary gravel, free from roots or loose rock, etc.	Fairly hard or tough clays, ordinary clay with some loose rock, shale, etc.	Mixtures of clay and hard rock, soft shale, and tough clays, etc.	Well-blasted rock, shale, etc.	Fairly well blasted rock, loose rock and tough clay with rock, etc.	Clay ground to a pulp with a lot of loose rock or earth	Poorly blasted rock or shale, boulders, hardpan, etc.
3 to 4	1							
4 to 5	7							
5 to 6	16							
6 to 7	2	16						
7 to 8		12						
8 to 9		5	11					
9 to 10			13		6			
10 to 11			28	6	2			
11 to 12				21	4			
12 to 13				11	9			
13 to 14				7	5		3	
14 to 15					9		2	
15 to 16					3	4	1	
16 to 17					2	10	1	1
17 to 18						7	4	
18 to 19						6		3
19 to 20						1	2	9
20 to 22								3
22 to 24							1	7
24 to 26								4
26 to 28								1
28 to 30								
30 to 35								2
35 to 40								
Average time of hauling in seconds	5.2	7.1	9.4	11.9	12.4	17.6	17.4	25.9

Table V.—Comparison of Combined Swing and Return Time for Various Types of Power Shovels. [The values are averages from field studies, under ordinary operating conditions]

Angle of swing	Gas shovel	Steam shovel	Gas and air shovel	Gas shovel
	Seconds	Seconds	Seconds	Seconds
30°	8.2	8.0	8.2	8.7
60°	10.4	9.0	9.0	9.4
90°	12.5	10.0	11.5	11.2
120°	14.6	11.0	13.2	13.9
180°	19.0	12.9	16.5	19.3
240°	21.4	14.9	19.8	24.8
270°	23.5	15.9	21.5	27.5

Slow Loading May Be Caused by Several Factors.—The position of the shovel with reference to the face of cut is in no small degree responsible for the repeated passes some shovel runners make in filling the dipper. The dipper is actuated by two separate and distinct motions—one, known as the "hoist," tends to raise the dipper in a vertical circle about the point of intersection of the boom and the dipper stick, while the other, known as the "crowd," controls the length of the radius of the arc in which the "hoist" moves the dipper. In loading, the "crowd" is used to force the dipper against the face of the cut, and on the swing to spot the dipper correctly over the hauling unit. When the dipper stick is in a vertical position the combined motion of the "crowd" and the "hoist" can drive the cutting edge of the dipper almost straight forward several feet, and when the dipper stick is horizontal the "crowd" serves to hold the cutting edge of the dipper hard into the bank.

When loading the dipper from a bank less than 2 ft. high, direct thrust forward into the bank is required, while on a bank 6 or more feet high the loading is generally best done by a longer swinging motion in which a comparatively thin slice is cut from the bank. For some reason it appears to be difficult to find operators who will perform both operations equally well. To make the shovel function smoothly where the bank is low, it must stand close to the bank with the boom somewhat lower than normal and must be moved forward frequently. This is because the forward thrust of the dipper resulting from the proper combination of the "hoist" and "crowd" only reaches a relatively short distance. Cutting from a high bank is best done after the dipper has begun to turn definitely upward in its swing, which requires that the shovel should stand well back from the bank with the boom high. The superintendent who will watch this matter closely and drill his shovel runners in the proper positioning of the shovel for effective dipper loading will find the results gratifying.

In addition to these causes of slow loading, viz., poor handling of the dipper itself and improper position of the shovel with reference to the face of the cut, the material itself is responsible for a good deal of slow digging. Banks composed of good-sized rocks embedded in a stiff clay are particularly troublesome. The runner can not see such rocks, and when the dipper strikes one it may be necessary to draw back and try again. Often two or three passes must be made—sometimes twice that many—before either a load of loose material is secured or the exact position of the rock defined so that it can be picked up.

Tables III and IV show something of the effect of the material on the time required for filling the dipper. Table III contains a few good illustrations of fast work in good common by shovel No. 1. A comparison of these tables will give a very fair impression of the difference between work in good ground and work in difficult material. They do not show the quantities moved, but, in general, fast operation in good material was accompanied by large dipper loads and the quantity decreased with difficulty in loading as indicated by the time factor.

Large Angle of Swing Causes Considerable Time Losses.—Figures 13 to 15 show the time consumed in making the swing and returning the dipper for various angles of swing on three jobs. Under perfect operating conditions curves showing the rate of swing would probably be straight lines except for

Handling Difficult Material Greatly Increases the Cycle Time

the influence of acceleration. That the points for one set of final observations do not all fall on the same line is due to the fallibility of the operator and the many other factors influencing performance; each individual swing ordinarily being subjected to a set of conditions different in some particular from the others.

The curves have not been projected to intercept the x-axis, since measurements were not made of the time loss in accelerating the dipper, but inspection of these and other graphs not shown indicates that the x-axis intercept or lag in getting the dipper started on the swing is variable for different shovels. It appears that the types of shovels with a slow-swing speed have a shorter lag, so that the actual time required for the swing and return, as shown in Table V, is often as short or shorter for the slow-speed types so long as the angle of swing is small, but on the longer swings the higher speed types are considerably faster. Figs. 16, 17, and 18 also show the variations found in the swing and return time under actual field operation.

The portion of the swing and return time which has here, for want of a better term been designated as the "lag" is evidently the sum of two or more factors. Time is required for the operator to react and manipulate the necessary mechanism, and it is also required to accelerate the shovel and its load from rest and again to decelerate it at the end of the swing. While it is very difficult to separate the lag into its purely personal and mechanical factors, the studies show very conclusively that the personal element involved is sufficiently large to warrant careful consideration because of its effect on the rate of production. For a good operator these reaction lags are small —generally less than one second. For a slow operator they will run twice this or even more. The difference of one or two seconds seems like a trifling matter, but the use of an operator who, because of these losses, takes 18 seconds where only 15 are necessary, reduces the rate of production almost 17 per cent. To change an operator making a load every 18 seconds for a man who takes 20 seconds reduces the rate of output about 10 per cent. With a good wagon supply and production running at a high rate, this can easily reduce the value of the output secured from $20 to $25 a day—about twice the ordinary wages of a first-class operator. It never pays to hire cheap, poorly trained operators on any sort of work requiring fast, unifom, consistent operation, and there is no point in highway work where this is more true than on power shovels.

Reverting to the swing itself and starting with the 90° swing (loading at the side of the shovel) which in good common and under favorable conditions can be done in 15 seconds, an extension of the swing to 180° (loading back of the shovel) extends the cycle by from three to eight seconds, depending on the type of shovel used and the skill of the operator. As a general average it may be said that loading behind the shovel extends a 15-second cycle to 20 seconds, and by so doing reduces the attainable rate of output 25 per cent.

There is much work where loading at the side of the shovel is impossible, largely because of narrow cuts. Deep cuts sometimes make loading at the side impossible if the whole cut is taken out at one operation. In general, however, there are many more situations where side loading could be practiced than are now utilized. Many contractors apparently feel that there are so many places where side loading can not be done that nothing substantial can be gained by training their men to utilize such opportunities as occur. The advantage of such methods depends largely on the available supply of transportation which will be discussed in a following article.

Extending the average swing to 270° is unqualifiedly objectionable and especially so where slow-swing shovels are used. This extends the cycle to 25 or more seconds and correspondingly reduces the rate of output. Such operation may be caused by a cab arrangement where it is hard for the operator to see out of one side of it. To avoid swinging his load over objects he can not see clearly and running the risk of dropping material on men or animals he can not see, the longer swing is sometimes used. Poor vision also interferes with spotting the dipper exactly

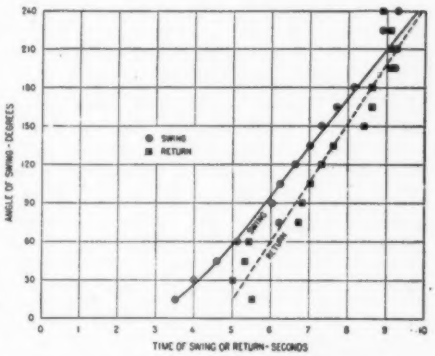


Fig. 14.—Influence of Angle of Swing on Time of Swing and Return Based on 2,069 Operations of a ¾-Yd. Shovel Working in Clayey Gravel. Average Rate of Swing 37.5° Per Second. Average Rate of Return 46° Per Second

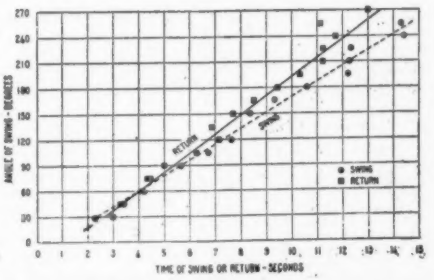


Fig. 15.—Influence of Angle of Swing on Time of Swing and Return, Based on 1,788 Operations of a ¾-Yd. Shovel Working in Gravel and Loose and Blasted Shale. Average Rate of Swing, 18° Per Second. Average Rate of Return, 22° Per Second.

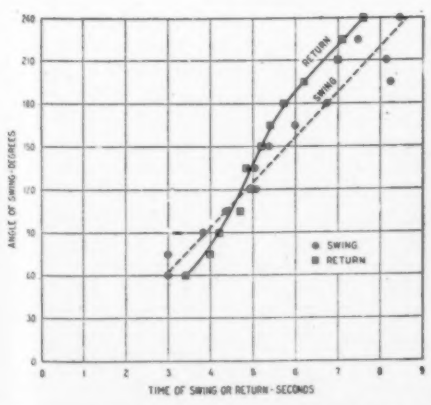


Fig. 13.—Influence of Angle of Swing on Time of Swing and Return Based on 506 Operations of a ¾-Yd. Shovel Handling Poorly Blasted Rock. Note that the Points Located for Time of Swing Are Much More Irregular Than Those for Time of Return. This Is Explained in Part by the Extra Care Required in Handling Bowlders. Average Rate of Swing 32° Per Second. Average Rate of Return 46° Per Second

A Full Dipper Load Being Spotted for Dumping

Table VI.—Time Required to Load, Swing, Dump, and Return Shovel on Various Jobs Where the Swing Varied from 30° to 270° and on the Same Jobs Where It Did Not Exceed 90°

Shovel	Readings	Load	Swing	Dump	Return	Total cycle
	Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
ANGLES OF SWING FROM 30° TO 270°						
Type A, Delaware County, N. Y.	2,033	12.8	4.6	3.7	4.2	24.3
Do.	1,796	12.7	5.3	4.0	7.5	33.5
Type B, Pike County, Pa.	2,042	9.7	6.1	3.3	6.3	25.4
Type C, Pike County, Pa.	2,069	10.0	7.1	4.4	7.6	29.1
Type D, Columbia County, N. Y.	869	10.2	5.3	3.0	5.4	24.5
Type E, Hughes County, Okla.	1,734	9.4	4.5	2.1	5.5	21.5
ANGLES OF SWING 90° OR LESS						
Type A, Delaware County, N. Y.	1,781	11.9	4.2	3.5	3.6	22.2
Do.	645	13.6	4.3	3.0	4.1	24.9
Type B, Pike County, Pa.	1,625	8.9	4.6	3.9	5.2	23.6
Type C, Pike County, Pa.	694	10.9	5.3	3.5	5.9	24.7
Type D, Columbia County, N. Y.	549	11.0	3.9	3.2	3.8	20.9
Type E, Hughes County, Okla.	1,677	9.3	4.4	2.1	5.4	21.3

before dropping the load. Hauling units are usually placed for a swing from one side. This is important if rock is being handled, for while a good operator seldom drops any material it takes very little to seriously injure a man or an animal. As a general rule, it may be said that an average swing of much over 180° is the result of improper equipment or faulty operating methods, but that occasions may arise when it is better to make a few 270° swings than to change the loading position of the hauling equipment.

Table VI shows the average time used in loading, swinging, dumping, and returning the dipper for several jobs where the swing ranged from 30° to 270° and when the swing was 90° or less. It is apparent that when the point of loading and the point of dumping are within the operator's vision at the same time he can keep his mind far enough ahead of his work so that his general reactions are faster and all of his operations are conducted with more confidence. As he digs his load he determines where he will dump and the manipulations necessary in the process. As he drops it he determines where he will get the next bite, and so on. The saving in time is small per load, but it is enough to make considerable difference in the day's run.

Dumping the Dipper.—The next item in the list going to make up the full cycle is discharging the load. This is an operation which requires great skill if it is to be done rapidly. The load must not be dropped from too great a height or the wagon will be damaged, and it must not be dropped too soon or too late or much of it will fall outside of the wagon. If the load is composed of loose common—light loam, sand, loamy clay, or rather fine gravel—an experienced shovel runner will drop it just as the swing ends and be ready to start the return as soon as the dipper comes to a stop. In such material the fast operator really takes no time to drop the load, the time consumed being only that needed to stop the dipper and then start it on the return swing, and this can be done regularly in one second. Wet, sticky clays and other adhesive materials often require considerable shaking or jarring to get them out of the dipper. The time required depends on the skill of the operator, but more largely on the average amount of shaking and jarring necessary to get them out of the dipper. It is not unusual to find dumping time in sticky materials regularly running as high as five or six seconds, though it necessarily varies with the degree of adhesiveness of the material. Con-

Table VII.—Effect of Character of Material on Time Required to Load and Dump Dipper

Average Dumping Time	Seconds
Loamy and sandy soils	2.9
Wet and sticky clay	4.0
Rock, well blasted	4.4
Rock, poorly blasted	8.9

Character of material	Observations	Time to dump dipper	Time to load dipper
	Number	*Seconds*	*Seconds*
Loam and light clay	727	1.0	4.2
Do.	351	1.3	5.4
Loamy clay and soft shale	294	1.9	5.4
Soft shale	330	4.2	6.5
Sandy clay	249	3.0	7.4
Moist clay	90	2.4	8.0
Light clay, wet and gummy	173	4.0	8.1
Clay and surface loam	693	1.9	8.4
Sandy clay, moist to wet	340	4.8	8.5
Well blasted sandstone with 20 per cent light clay	229	1.8	9.3
Clay with a few bowlders	448	2.1	10.0
Heavy clay, wet and gummy	271	5.3	10.4
Clay with some surface bowlders	2,322	1.8	10.5
Loam with loose rock and loose shale	376	2.8	10.6
Do.	268	2.4	11.8
Clay-gravel	208	1.7	11.8
Heavy clay, wet and sticky	61	6.0	12.0
75 per cent loose shale with 25 per cent clay	279	3.2	12.4
Heavy clay with a few bowlders	101	3.0	12.5
Wet clay with some stumps	105	3.2	12.8
Loam with 30 per cent loose rock	148	2.1	13.5
Rock, well blasted	183	3.4	13.9
Do.	160	4.2	15.1
Hard shale, well blasted	1,434	2.6	16.4
Gneiss, poorly blasted	156	10.7	24.6
50 per cent loose rock with 50 per cent unblasted shale rock	230	.....	26.0

Table VIII.—Shovel Movements Classified According to Time Required

Time required (seconds)	Movements of crawler-traction shovels	Movements of wheel-traction shovels operating on mats	Time required (seconds)	Movements of crawler-traction shovels	Movements of wheel-traction shovels operating on mats
	Number	*Number*		*Number*	*Number*
8 to 10	6	.....	50 to 60	2	5
10 to 12	29	.....	60 to 70	1	12
12 to 14	32	.....	70 to 80	.....	28
14 to 16	20	.....	80 to 90	2	7
16 to 18	14	.....	90 to 100	.....	10
18 to 20	8	.....	100 to 125	.....	16
20 to 25	23	.....	125 to 150	.....	7
25 to 30	10	.....	150 to 175	.....	4
30 to 35	7	.....	175 to 200	.....	1
35 to 40	6	.....	Above 200	.....	6
40 to 50	6	3			

[1] Each of these curves (Figs. 16 to 19) is in reality formed from the sum of a number of superimposed curves having the general form of the skewed probability curve, but in the interest of clearness the points from actual field readings have been connected by straight lines.

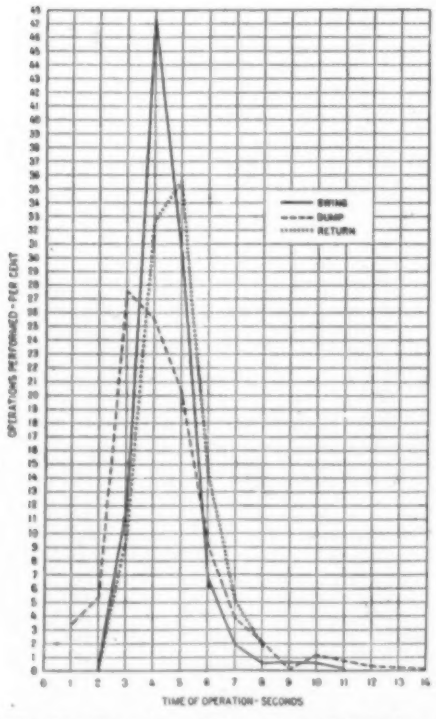


Fig. 16.—Percentage of Operations of Swinging, Dumping, and Returning Performed in Various Time Intervals[1] Based on 1,058 Cycles of a ¾-Yd. Shovel Working in Sticky Clay with an Angle of Swing of From 45° to 90°. Average Time of Swing, 4.42 Seconds. Average Time of Dumping, 4.31 Seconds. Average Time of Return, 4.86 Seconds

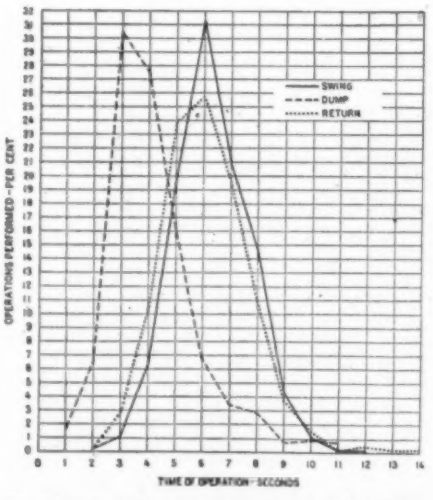


Fig. 17.—Percentage of Operations of Swinging, Dumping, and Returning Performed in Various Time Intervals.[1] Based on 658 Cycles of a ¾-Yd. Shovel Working in Sticky Clay with an Angle of Swing of From 150° to 180°. Average Time of Swing, 6.23 Seconds. Average Time of Dumping, 4.33 Seconds. Average Time of Return, 6.10 Seconds

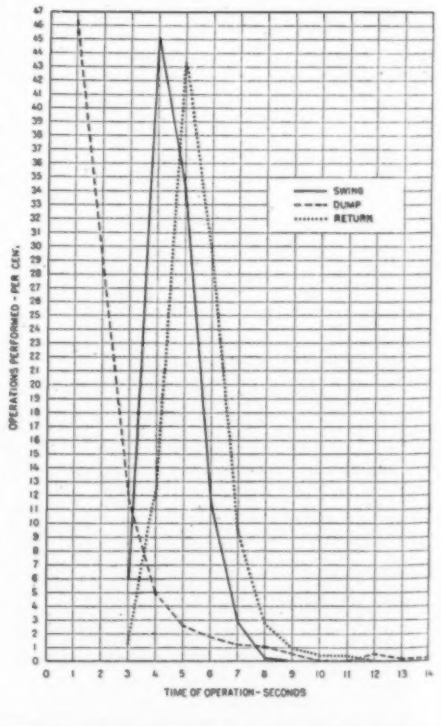


Fig. 18.—Percentage of Operations of Swinging, Dumping, and Returning Performed in Various Time Intervals. Based on 1,322 Cycles of a 1½-Yd. Shovel Working in Clay with Some Bowlders with an Angle of Swing Varying from 45° to 90°. Average Time of Swing, 4.62 Seconds. Average Time of Dumping, 2.23 Seconds. Average Time of Return, 5.49 Seconds

siderable care must be taken by the operator to prevent injury to the wagons or trucks, which naturally slows down the rate of operation and large chunks often hang or wedge in the dipper and require manipulation to release them. Roots and stumps are often very troublesome in this respect.

Table VII shows how the average dumping time is affected by the kind and character of the materials found from one-hour stop-watch studies. Figs. 16, 17, and 18 show the time used in dumping material from the dipper into the wagons or trucks under typical conditions. Fig. 19 shows the average dumping time for a number of classes of material as found from the analysis of 10,200 readings secured on 13 different jobs with various grades of operators and six different makes of shovels. It will be noted that a considerable percentage of the operations were performed very rapidly.

Crawler-Traction Shovels Have Big Advantage in Speed of Movement.—The movement of the shovel within the cut to keep within easy reach of the face constitutes a definite limitation to uninterrupted repetition of the dipper cycle and is a check on production which can not be entirely removed. The best that can be done is to train the operator to make these moves as expeditiously as possible. In deep cuts the time required is small, generally less than 1 per cent, where shovels with the latest crawler-type traction are used. In shallow cuts, however, the proportion mounts very rapidly and cases where 8 to 10 per cent of the total time is used in moving the shovel are not uncommon, especially where the operator is slow or where the mechanism is in poor condition. Because of the general prevalence of insufficient hauling equipment it has become a more or less accepted practice to consider the time required for moving the shovel as of no importance, since it can usually be done while waiting for teams or trucks. This may seem like a good way of neutralizing an inherent shortcoming of the shovel, but it is one which is rather hard on the profits which might otherwise be had from the job.

Table VIII shows a number of typical readings of the time required to move both crawler and wheel-traction type shovels under fair to good field conditions. The average time required for moving the wheel-traction type operating on mats was more than five times that required for moving the improved crawler type. In shallow cuts where much moving is required the shovel equipped with wheel traction operating on mats is under a severe handicap. This is also true for some of the older crawler types which normally require an additional man when moving. In general, and under fair field conditions, it should be possible to keep the average time per move for a ¾-yd. crawler type shovel of the better type within 15 seconds and within 75 seconds for a similar shovel equipped with wheel traction and operating on mats. If the average time per move approaches 30 seconds under ordinary field conditions for the crawler shovel or 150 seconds for the wheel shovel, we may safely conclude that either the operator is slow or the mechanism needs adjustment or repair. For blocking or leveling the shovel on steep grades at least two wide wedge-shaped blocks reinforced with strap iron and light bolts should be provided. Such blocks can readily be handled by the pitman and will pay for themselves in a few hours where conditions are such that blocking is required.

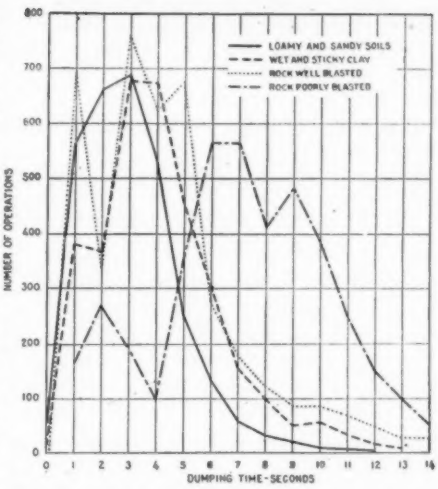


Fig. 19.—Number of Dumping Operations Performed in Various Time Intervals in Different Kinds of Material. Based on 10,200 Observations on 13 Different Jobs

Shovel Operator a Most Important Factor.—A high degree of efficiency in power-shovel operation can only be secured through the proper coordination of several factors. The first and most apparent is the operator. The ideal operator is a man gifted with quick reaction, a true eye, good judgment, great endurance, and a high degree of skill and experience. He should know the possibilities as well as the limitations of the shovel and be able to maintain it in first-class condition.

But it is not enough simply to secure a good operator. Except where casting is involved, the operator can dig no more material than the available equipment can haul, and he can only dig when hauling units are actually in place for loading. If the supply of wagons or trucks is inadequate to handle full shovel production, or if their operation is such as to interfere with the steady, methodical operation of the shovel, the fault lies with the management.

Highway Construction in Colombia.—The Department of Caldas, Colombia, has negotiated a $12,000,000 loan which will be used principally for construction, including highways. A $4,000,000 loan has been negotiated by the Department of Cundinamarca for public works including highways.

Cost of Constructing Three Concrete Box Culverts

We are indebted to Mr. H. A. Little, County Engineer of Taylor County, Bedford, Ia., for the following costs on day labor, concrete box culvert construction. He states that the labor charge includes excavation costs. This cost in Taylor County will run around $2.00 per cu. yd. Job No. 1 had about 49 cu. yds. of excavation, Job No. 2 had only a little excavation and Job No. 3 had about 33 cu. yds. of excavation. The haul on the three jobs was about 4 miles each.

JOB NO. 1

5 ft. by 4 ft. Reinforced Concrete Box Culvert (Iowa Standard). Span, 5 ft., Length, back to back of parapet walls, 38 ft., Cu. Yds. Concrete, 32.0

Item	Quantity	Rate	Amount
Foreman	97 hrs.	$0.55	$ 53.35
Foreman team	97 hrs.	0.20	19.40
Truck drivers	80 hrs.	0.45	36.00
Laborers	485 hrs.	0.30	145.50
Aggregate	53.35 tons	2.04	108.83
Cement	211 sacks	0.60	126.60
Steel	25.60 cwt.	3.02	78.59
Lumber			15.00
Hardware (Nails, etc.)			5.00
Gas and oil			27.84
Subtotal			$616.11
Repairs to equipment@$1.25 per cu. yd.			40.00
Depreciation on equipment@$0.75 per cu. yd.			24.00
Total			$680.11
Cost per cu. yd.			21.25
Labor cost per cu. yd.			7.94

JOB NO. 2

6 ft. by 4 ft. Reinforced Concrete Box Culvert (Iowa Standard). Span, 6 ft., Length, back to back of parapet walls, 53 ft., Cu. Yds. Concrete, 50.7

Item	Quantity	Rate	Amount
Foreman	240 hrs.	$0.55	$132.00
Foreman team	240 hrs.	0.20	48.00
Foreman mixer	15 hrs.	0.50	7.50
Form builder	235 hrs.	0.40	94.00
Laborers	855 hrs.	0.30	256.50
Truck drivers	174 hrs.	0.45	78.30
Gravel	55.65 tons	2.53	140.96
Sand	49.75 tons	1.80	89.14
Cement	352 sacks	0.65	228.80
Steel	45 cwt.	3.02	135.90
Form Lumber			25.00
Hardware (Nails, etc.)			5.00
Gas and oil			35.49
Subtotal			$1,276.59
Repairs to equipment@$1.25 per cu. yd.			63.38
Depreciation on equipment@$0.75 per cu. yd.			38.03
Total			$1,378.00
Cost per cu. yd.			27.19
Labor cost per cu. yd.			12.15

JOB NO. 3

4 ft. by 3 ft. Reinforced Concrete Box Culvert (Iowa Standard). Span, 4 ft., Length, back to back of parapet walls, 35 ft., Cu. Yds. Concrete, 23.6

Item	Quantity	Rate	Amount
Foreman	65 hrs.	$0.55	$ 33.75
Foreman team	65 hrs.	0.20	13.00
Truck drivers	96 hrs.	0.45	43.20
Laborers	325 hrs.	0.30	97.50
Gravel	40 tons	1.80	72.00
Cement	160 sacks	0.60	96.00
Steel	20 cwt.	3.02	60.40
Lumber			15.00
Hardware			5.00
Gas and oil			12.74
Subtotal			$445.65
Repairs to equipment@$1.25 per cu. yd.			29.50
Depreciation on equipment@$0.75 per cu. yd.			17.70
Total			$492.85
Cost per cu. yd.			20.83
Labor cost, per cu. yd.			8.03

Wear Tests of Concrete

Tests to determine the abrasive resistance of concrete, made at the Engineering Experiment Station of the Kansas State Agricultural College, Manhattan, Kan., are described by C. H. Scholer, professor of applied mechanics, and Harold Allen, associate professor of applied mechanics, in Bulletin No. 20 issued recently by the college.

The first object of the test described in this bulletin was to develop a method of testing the resistance of concrete to wear which could be used in any laboratory having standard equipment. The second object was to study the effect of various factors on the resistance of pavement concrete to wear, viz.: (1) The variation of the French coefficient or resistance to wear of the coarse aggregate; (2) the variation of the water content; (3) the use of a patented surface hardener; (4) the replacement of a part of the Portland cement by natural or hydraulic cement; and (5) the use of Lumnite cement in place of Portland cement. The proportions used in the Portland cement concrete were 1:2:3½ and in the Lumnite cement concrete both 1:2:3½ and 1:3:5. Measurements of the aggregates were based on the dry and loose volumes.

The conclusions based on the tests are given as follows in the bulletin:

1. That the testing of three 9-in. spheres of 60-day concrete in a standard paving brick rattler for 900 revolutions is a satisfactory and convenient method of testing for the resistance to abrasion.

2. That the French coefficient of the coarse aggregate does not materially affect the resistance to wear or the strength of Portland cement concrete of a 1:2:3½ mix by dry, loose volumes; that is, good results may be obtained by the use of any coarse aggregate which is structurally sound.

3. That the use of the surface hardener made up and applied as in these tests increases the resistance of concrete to abrasion.

4. That proper curing is necessary to produce concrete which will have a high resistance to wear.

5. That the use of an excessive amount of mixing water will reduce the resistance to wear of concrete in about the same proportion as it will reduce the strength.

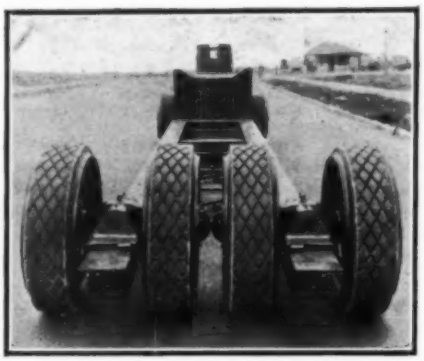
6. That the relation of the wear and strength of concrete is expressed by an equation of the form: $A = \frac{K}{S^n}$; in which A = wear in inches; S = compressive strength in pounds per square inch, and K and the component n are constants.

7. That the replacement of 12½ per cent or more of the volume of the Portland cement with natural hydraulic cement in a 1:2:3½ mix by dry and loose volumes will reduce the strength of the concrete and the resistance to wear in proportion to the amount of Portland cement replaced.

8. That Lumnite cement concrete of the same proportions as Portland cement concrete will have about the same resistance to wear at 48 hours that Portland cement will have at 60 days.

Trailer Conforms to Load Laws and Saves Time

The growing practice of contractors to move their slow moving equipment from job to job at truck speed on heavy duty trailers has brought out the design of trailers such as the one illustrated on this page. Here is the Type H Carryall, a six-wheel heavy-duty drop-frame trailer manufactured by the Fruehauf Trailer Co., of Detroit, Michigan. It has been designed to meet current laws relating to the width and pavement loading of heavy-duty vehicles, and has features that afford long life, speedy hauling, and convenience in loading and unloading.



The Rear End of the Fruehauf Trailer, Type H Carryall, Showing the Rear Wheels on Trunnion Axles

The main frame is built of heavy H beams, latticed for reinforcement, while the rear wheels are mounted on trunnion axles to permit them to follow any road contour, and to balance the load. Heavy machines, such as tractors, can straddle the frame and be carried with their axles resting on the beams, or a platform body may be made by laying heavy boards crosswise on the beams.

The rear wheels are easily and quickly removable to permit the load to be run up onto the beams and are as quickly replaced as soon as the trailer has received its load. A jack and wrench are the only tools needed.

Gasoline Consumption by Motorists Increased 8 Per Cent Last Year

Taxation of gasoline in 1927 produced a total net revenue of $258,966,851, according to information collected from state authorities by the Bureau of Public Roads of the United States Department of Agriculture. Of this, $182,095,503 was available for the construction and maintenance of state highways under the supervision of the state highway departments and $55,440,161 was apportioned to counties for local road purposes. All but 4 per cent of the net receipts were allotted for road purposes, including the payment of interest and retirement charges on highway bonds. The yield of the tax constituted an important contribution to the total highway revenue.

The tax was collected in every state but Massachusetts and New York, the rate ranging from 2 to 5 ct. per gallon.

The returns indicate an increase in gasoline consumption over 1926 in all but two states. Including estimates for the two states in which tax was not imposed, it is indicated that 10,596,000,000 gal. of gasoline were used by motor vehicles during the year, an increase of 8.2 per cent over 1926. The average consumption per motor vehicle was 458 gal.

The following tabulation shows the tax rate on Jan. 1 and Dec. 31 and the net receipts after the deduction of refunds:

State	Tax rate Jan. 1, 1927 Cents per gallon	Tax rate Dec. 31, 1927 Cents per gallon	Net receipts from gasoline tax
Alabama	2	4	$ 5,908,986
Arizona	3	4	1,388,830
Arkansas	4	5	4,338,737
California	2	3	22,467,083
Colorado	2	3	3,139,594
Connecticut	2	2	3,054,906
Delaware	2	3	662,159
Florida	4	5	10,980,586
Georgia	3½	4	7,066,109
Idaho	3	4	1,571,749
Illinois	0	2*	6,199,509
Indiana	3	3	10,133,568
Iowa	2	3	7,248,214
Kansas	2	2	4,594,650
Kentucky	5	5	5,913,396
Louisiana	2	2	3,034,056
Maine	3	4	2,288,933
Maryland	2	4	4,169,397
Massachusetts	0	0	.....
Michigan	2	3	14,260,564
Minnesota	2	2	5,174,880
Mississippi	4	4	4,890,686
Missouri	2	2	6,330,983
Montana	3	3	1,436,398
Nebraska	2	2	3,664,919
Nevada	4	4	471,624
New Hampshire	2	3†	1,268,907
New Jersey	0	2	4,082,860
New Mexico	3	5	1,415,690
New York	0	0	.....
North Carolina	4	4	8,786,682
North Dakota	2	2	1,275,565
Ohio	2	3	19,910,481
Oklahoma	3	3	7,197,956
Oregon	3	3	3,643,191
Pennsylvania	2	3	17,296,333
Rhode Island	1	2	915,959
South Carolina	5	5	5,080,385
South Dakota	3	4	2,393,592
Tennessee	3	3	4,476,180
Texas	1	3	15,650,841
Utah	3½	3½	1,461,261
Vermont	2	3	905,244
Virginia	4½	4½**	7,139,707
Washington	2	2	3,821,438
West Virginia	3½	4	3,794,068
Wisconsin	2	2	6,027,114
Wyoming	2½	3	756,049
Dist. of Columbia	2	2	1,148,794
Average	2.76	Total	$258,838,813

*Tax in effect 5 months in 1927 and discontinued Feb. 25, 1928.
†Gasoline tax became 4 cts. on Jan. 1, 1928.
**Increased to 5 cts. on March 19, 1928.

The New Model Municipal Traffic Ordinance

An Interesting Discussion of Principal Features of New Ordinances

By S. J. WILLIAMS
Director, Public Safety Division, National Safety Council

WE have in this country about one hundred million traffic experts, this being the approximate total of our population old enough to talk and young enough to walk. These have nearly one hundred million different ideas on how to solve our traffic problems, but on one point they all seem to agree—that there should be uniformity of traffic regulations in the various states and cities. An eloquent discussion on this subject, all one-sided, can be induced in any traffic convention, luncheon club or Pullman smoker. The usual opening is—"Why, I drove down to Philadelphia the other day, and when I started to make a left turn the cop stopped me and said, 'Where do you think you are going?' and I said——," and so on.

There are few things in which we, the people of the United States, are so unanimous as in our desire for uniformity in traffic regulation. Still we do not get it—at least, we have not gotten it so far. Why?

There must be, and there are, reasons for their inconsistency. Some of these are logical, some are illogical, all are powerful.

Effect of Local Conditions.—One of the real difficulties is the differing conditions in different parts of the country. These are human rather than physical differences. Variations in climate and topography do not play a large part, but differences in laws and customs do. The populous communities of the North Atlantic are accustomed to concentrated governmental control to a degree that is repugnant to the sparsely settled regions of the Southwest. That is the chief obstacle that we meet in seeking enactment of the drivers' license laws in the West and South. However, this has little bearing on municipal ordinances and regulations. It seems to be generally agreed that the proper uses of the streets should be defined by ordinances, and that these regulations should be enforced by the police, in any community large enough to have any traffic problem, whether located in New York or Arizona.

There is one constitutional matter that must be attended to by the framers of traffic ordinances. The relation between the state law and city ordinances differs in different states. In some states it is necessary or desirable for the ordinance to repeat some or all of the provisions of the state law. In other places this is unnecessary and undesirable. This, however, is simply a technical matter for the legal draftsman and not particularly difficult if we have once agreed on what are the proper provisions of the state law and the city ordinance.

Differing Opinions as to Best Way to Handle Traffic.—A greater obstacle in the path of uniformity is this fact, which we as administrators and engineers might as well face frankly. On some rather important items we still do not know what is the best way to handle traffic. Put into one room a group of ten or twenty public officials and engineers from different parts of the country, honest, competent men, experienced in traffic control, and ask them whether the yellow or amber color should be used in signal lights in addition to the red and green. You will find them totally unable to agree. There are good arguments, both theoretical and practical, on both sides. You in New York State, I understand, are pretty well committed to the two color system, omitting the amber. You may be right but I am not at all sure you are. If you are in any measure following the example of our metropolis, New York City, which has done so many fine things in the field of city administration, I respectfully call your attention to the fact that New York City has a three color signal system, except that the middle color, the interval between the green and the red, is dark! I honestly do not know whether the two color or the three color traffic control system will eventually prevail in this country. We must experiment with both for a few years more. All we can do at this time is to agree that when the three color system is used the colors shall have certain standard meanings; and the same with the two color system.

There are a few other matters on which there is still an honest difference of opinion among experienced men. One of these is the method of making left turns. Here there is a decided majority opinion which is expressed in the Model Ordinance which I shall mention in a moment, but there is also a minority opinion.

A Real Difficulty.—These are the real logical difficulties in arriving at uniformity. There is another difficulty, much greater, but totally illogical. That difficulty is this: Everyone wants uniformity, but his idea of uniformity is to have you adopt his ordinance. His ordinance has above it a certain halo, it is invested with the odor of sanctity, it is bound up with the memories and the reputation of the distinguished citizens, lawyers, administrators, who worked it out with blood and tears. This sentiment does credit to the loyalty of our community leaders but it does not lead to uniformity. If we really want uniformity, if we want to be able to drive from Boston to Washington without violating some local rule for every mile we travel, we must be willing to give up something for it.

It is important also to consider just what sort of regulations need to be uniform. The greatest need is for harmony in what we call the rules of the road. The methods of overtaking and passing, of turning, of stopping or starting; the permissible speed limits under given conditions; the meaning of traffic signals and of signals given by the motorist; the sort of headlights and brakes that are to be required—these are the things on which lack of uniformity drives the motorist to distraction and contributes to congestion and accidents. If it is possible to work out, on these points, suitable rules stated in simple language that everyone can understand, it would obviously be best to have these rules adopted verbatim by every state and city just as we now have a standardized wording of insurance policies, bills of lading and other legal documents in universal use.

The Police Authority.—When it comes to the authority of the police and other officials, it is desirable to have substantial uniformity although the exact wording may not be so important. On a subject like parking, the detailed regulations will necessarily differ in every city. What we can have, on parking, is some uniform method of treating the subject and a uniform method of indicating, by signs, just what the regulation is on each street and in each block. On still other subjects such as the legal procedure in making an arrest, the establishment of local traffic commissions and traffic engineers, and so on, our cities can well profit by each other's experience, but exact uniformity is neither practicable nor necessary.

Recognizing all these difficulties and reservations, it is still possible to say today, for the first time, that the people of the United States have before them a real opportunity to obtain reasonable uniformity in traffic regulations. This opportunity has come about because the United States Government, through Secretary Hoover and the Department of Commerce; most of the larger state and city governments; and all the national oganizations interested in the subject, have come to realize both the need for uniformity and the difficulties in getting it—both the importance of doing this job and the vital

need for doing it in the right way. Nearly a year ago a high grade committee of public officials, traffic engineers and representatives of other interested groups was brought together on appointment by the Secretary of Commerce and with the full endorsement and support of the official automobile, commercial, insurance, engineering, and safety organizations of the country. As a member of the committee I can testify that the remainder of the personnel is at least the equal, in experience, ability, and devotion to the public welfare of any group ever organized for any similar purpose. The committee has utilized the services of the best experts in the country on the legal, engineering, administrative and other phases of municipal traffic regulation and its work has been based on a careful study of the ordinances of more than 100 American cities and especially the model ordinances already developed by regional groups in Michigan, California, Colorado and Minnesota.

As the result of a year of hard work the committee has printed and distributed the tentative draft of a Model Municipal Traffic Ordinance, which is now before the cities and the people of the United States for their consideration. It is possible at this time to mention only a few of the high points in this Ordinance. In general it is, of course, consistent with the Uniform Vehicle Code previously developed by the National Conference on Street and Highway Safety as a model for state legislation, this state code being very similar to the present laws of New York, Pennsylvania, and the New England states.

Following the definitions in Article I, Article II of the Model Ordinance contains the usual provisions authorizing the police to direct traffic and requiring obedience to them, also requiring public employees to obey the regulations the same as private citizens. The only exception is in the case of emergency vehicles, which are defined as including vehicles of the Fire Department, Fire Patrol, Police and such ambulances and other emergency vehicles as are designed by the Chief of Police. Even such vehicles are exempted only when actually on an emergency errand.

Uniform Signs and Signals.—Article III deals with signs and signals. It is provided here and elsewhere that certain of the regulations, such as those relating to parking, must be set forth for the information of motorists by means of suitable signs and are not enforcible unless such signs are in place. The sign and signal system is to be uniform throughout the community as far as practicable. The meaning of the various signal colors is clearly defined, whether the two color or three color system is used. Such definitions are, of course, entirely consistent with the report, about to be published, of a Committee of American Engineering Council, which goes much further into detail in the specifications for and use of traffic signs and signals. The Model Ordinance provides that all movements shall be made on the green light only, right or left turns on the red light not being permitted. If it is desired to permit turns to be made at any specified location, at a time when other forward movement is not permitted, a special indication is to be given by means of a green arrow pointing in the direction of the permitted turn. This article also contains an important section prohibiting the display on or near any street, of any unofficial sign, signal or device which in any way resembles an official traffic sign or signal. In many cities the display of electric and other signs which, intentionally or unintentionally, imitate traffic signals has become a positive nuisance.

Pedestrians' Rights and Duties.—Article IV deals with the vital subject of pedestrians' rights and duties. The recommended rule is that vehicles shall yield the right-of-way to pedestrians at cross-walks and that pedestrians shall yield the right-of-way at other places. At an intersection controlled by traffic signals or officers the pedestrian or vehicle crossing with the signal is given the right-of-way. The committee seriously considered the rule now in force in several cities of the country requiring unqualified obedience to the traffic signals by pedestrians as well as vehicles and prohibiting pedestrians from crossing other than at cross-walks. The unanimous conclusion of the committee was that this drastic regulation can be successful only where the city has made careful preparations to insure obedience to it by both educational and enforcement methods and that the premature enactment of such a provision in a city not so prepared will do more harm than good. However, an alternative section providing for complete pedestrian control is submitted for those cities that are ready for it.

Article V deals with street cars and railroad trains. Passing a standing street car is prohibited except where there is a safety zone. Driving through a safety zone at any time is forbidden. The Model Ordinance Committee joins with the Committee of American Engineering Council in urging that when a safety zone is established at all, it should be marked by something more substantial than lines on the pavement —preferably a permanent or at least a substantial temporary obstruction at the end to furnish an unmistakable indication to the approaching driver.

Stopping, Standing and Parking.—The next article deals with the much discussed subject of stopping, standing and parking. Stopping at any time or for any reason other than to avoid accident or obey a police order is forbidden at certain places, such as within an intersection or cross-walk, opposite a safety zone, within 15 ft. of a cross-walk on the near side, and at other locations commonly so treated. The local authorities are empowered to set aside certain places for the loading and unloading of passenger vehicles only and other places for the loading and unloading of passenger or freight only, also to set aside taxicab stands. Skeleton sections are provided for prohibiting parking longer than a certain time limit in specified places and, if desired, prohibiting it entirely in other places.

Article VII on the operation of vehicles includes the customary rules of the road that are considered necessary in a city ordinance. It is provided that all turns shall be made from the lane or line of traffic on the side toward which the vehicle is turning, and that left turns shall be made around the center of the intersection unless some other path is indicated by markers. The making of a complete reverse turn is prohibited at any intersection where the traffic is controlled, it being considered that such intersections are too busy to permit the delaying of traffic by such turns. An optional section prohibits making a reverse turn in mid-block in any business district or on a through street in a residence district. Another section establishes certain streets as through streets and requires all vehicles on intersecting streets to stop before entering or crossing. After coming to a stop, such vehicles are then subject to the usual right-of-way rule the same as other intersections.

Article VIII contains various miscellaneous provisions and Article IX specifies the penalties and procedure on arrests.

In many states it is considered unnecessary for city ordinances to contain other provisions, such as speed limits, prohibition of driving while drunk, signals on stopping or turning, and the right-of-way rule as well as the requirements relating to brakes, headlights, etc. In case, however, the legal system in any city makes it desirable to incorporate such subjects in the city ordinance, the committee presents appropriate sections taken for the most part from the Uniform Vehicle Code.

Following the text of the ordinance is a very interesting discussion in which the reasons for the important provision are set forth. This constitutes, I believe, by far the best discussion now in print, of the subject of municipal traffic regulations. Following this is an appendix containing three additional short ordinances on subjects not properly included in the traffic ordinance itself. The first of these creates an official traffic commission for the municipality, consisting of specified city officials, connected in one way or another with the administration of traffic rules. The second creates the position of City Traffic Engineer. The third deals with the control of roadway and sidewalk obstruction, the committee believing that it is just as necessary to prevent the unnecessary obstruction of the streets by ditches, pavement repairs, the hoisting

of building materials and the like as by parked vehicles.

Ten thousand copies of this tentative ordinance have been printed and are being distributed throughout the United States to public officials, safety organizations, chambers of commerce, motor clubs, electric and steam railways, etc. Every one of these organizations and individuals has been earnestly requested to examine the ordinance and send in his comment or criticism to the committee at Washington by June 10 so that the committee may take final action thereon at a meeting to be held at the end of this month or early in July. On behalf not only of the National Safety Council but of all the organizations cooperating in this very necessary work, I want to leave with you a most urgent plea for your help. I hope that some of you have already looked at the printed ordinance which has undoubtedly been sent to you and that you will discuss it in some session of this conference or arrange for some committee to give it special consideration at this time or immediately after your adjournment. In addition to the action which we hope you will take as a state body, your individual comments are most earnestly desired. Additional copies of the ordinance may be obtained without charge from the Department of Commerce at Washington. It is only through earnest, unselfish cooperation that we shall ever be able to do away with the present complexity of local ordinances and regulations which forms so large a part of our traffic problem.

Acknowledgment.—The foregoing is an address presented June 6 before the New York State Conference of Mayors and Other Municipal Officials, Troy, N. Y.

State Highway Work in New York

Nearly $400,000,000 Spent Since 1906—Details of 1927 Work —Changes in Design

By DAVID NOONAN
Maintenance Deputy Commissioner, New York State Department of Public Works

The following are the total expenditures of the State Bureau of Highways for the past five years and the anticipated expenditure for the present year:

1923		$25,000,000
1924		33,000,000
1925		41,000,000
1926		38,000,000
1927		48,000,000
1928	Appropriations	50,000,000

City and State Outlay $1,000,000,000.—Figures compiled by the state comptroller's office show an aggregate of expenditures of nearly $400,000,000 since 1906, of which, roughly, $180,000,000 represents construction of state highways, $130,000,000 maintenance and repair, and $70,000,000 expended in aid of towns and counties and upon highway bridges.

The figures do not include what the cities in the state have expended upon traffic improvements, which, between 1920 and 1927, is rated at about $600,000,000. This represents the larger part of the financial strain which modern traffic has placed upon the cities and indicates an aggregate sum for city and state highway outlay in excess of $1,000,000,000.

Higher outlay of the cities is accounted for by the property damages involved, particularly in the demolition of buildings occasioned by new streets or widened thoroughfares.

Early History of State Road Building.—This state has been building roads since 1898. We were antedated by only one or two states in the Union and then by but a year or two. The history of those pioneer days, when not only traffic was light, but knowledge of road building as well, is an interesting as well as a fascinating subject.

The Higbee-Armstrong Act, the legislation putting into effect the machinery for road building and providing for the appropriation of the necessary funds, was passed by the Legislature in 1898 and the first state road was awarded in September of that year. Under this act the Board of Supervisors of any county could pass a resolution calling for the improvement of any road in the country. After approval of the resolution by the State Engineer, which was as a rule perfunctory, surveys and plans were made, and the road advertised for construction. The law provided that half the cost should be borne by the State and half by the county and town.

Up to Jan. 1, 1906, the State had appropriated over $3,200,000 and the counties over $9,500,000. Seven hundred and four miles had actually been placed under contract and petitions had been received for a total of 7,425 miles for the construction of which the various counties were urgently clamoring.

Early Types of Roads.—Our maintenance organization sometimes thinks that the present day Legislature is parsimonious in appropriations for road repairs and reconstruction. How thankful it should be that neither the Legislature nor the State Engineer could keep up with the petitions, in which case we would have had 7,425 miles under contract or built at this time. The only types of road built up to that time, and in fact until 1909, with the exception of a few miles of brick and Topeka, were waterbound macadam and gravel. Up to 1909, 2,075 miles of these types were placed under contract, of which 86 per cent was 6 in. and only 2.5 per cent more than 8 in. thick.

Under the Highbee-Armstrong Act the maintenance of roads was to be performed by the counties and the towns under the supervision of the State Engineer. The counties, however, were not compelled to raise money for this work and as a result but little was done and the roads began to deteriorate rapidly. There was considerable opposition to the first $50,000,000 bond issue in 1905 because no provision had been made for maintenance. Largely because of this opposition the sum of $550,000 was appropriated during 1906-1908 inclusive for maintenance, which was but a drop in the bucket so far as proper repairs were concerned, as it amounted to only a few dollars per mile for roads which had not been touched in some cases for five years or more.

Maintenance Department Formed in 1909.—This neglect was one of the contributing factors toward the formation of the Highway Commission in 1909, which took over the Highway duties formerly performed by the State Engineer. A Maintenance Department was formed at that time and definite appropriations made each year to care for maintenance and reconstruction. The sum for the first year was $1,500,000, which has been gradually increased until in 1928 $20,000,000 has been appropriated for Maintenance and Reconstruction. The total amount appropriated since 1909 totals more than $157,000,000 in addition to several millions of tax money and county, town and village participation.

The Highway Department does not advocate heavy reconstruction by departmental forces. We find that the cost approximates that of contract work. Furthermore we do not feel that such work should be taken from contractors who are equipped for it and expect to be allowed to bid on it. There are instances, however, when reconstruction of short stretches by departmental forces is to the best interest of the State.

Work Done Last Year.—The year just ended has been the best as far as construction operations are concerned that the Department has ever had.

Weather conditions were the best since 1921, the banner year for road building since the war. This, combined with an easy labor situation, good material conditions, and vast improvements in road building machinery and methods, has enabled the contractors to lay much more pavement than has been the case in the past few years, particularly 1926, which was one of the most disastrous we have ever had because of an extremely wet summer and fall and a winter which set in unusually early.

During the past year 668.81 miles, representing 8,241,266 sq. yd. of pavement, were laid, which compares most favorably with 498.03 miles and 5,513,146 sq. yd. laid in 1926. This record is considerably short of 1921 when 774 miles of pavement were built, but the square yardage is greater by more than 600,000 because the average width of pavement laid in 1927 was 20.30 ft. while the average width placed under

contract in 1921 was only 16.67 ft. Although records of mileage and yardage constructed each season before the war are not available, it is reasonably certain that the yardage laid in 1927 has never been exceeded.

During the year 161 contracts covering 684.05 miles of roads and bridges were accepted as against 117 contracts covering 488.89 miles in 1926.

Sixty-eight new construction contracts covering 312.37 miles of highways and bridges, at a total contract price of $16,242,373.37, were executed during the year. This compares with 59 contracts covering 283.54 miles in 1926 and 62 contracts, totaling 369.19 miles, in 1925. During the latter year, however, grading contracts took up 100.65 miles of the total, while in 1927 this type of work covered but 38.62 miles.

Types of Pavement.—The majority of the mileage awarded has been of reinforced concrete construction but more contracts than usual have called for a bituminous macadam pavement. In many sections of the State, particularly in the Adirondack and Catskill regions, where there is no local sand but an abundance of stone, it is much more economical to build the latter type. But it is by no means the same 6 in. to 8 in. macadam highway that was built previous to 1919 and which is now causing so much trouble and expense to maintain. All macadam pavement now consists of a 9 in. foundation, 3 in. bottom and 3 in. top course, giving a total thickness of 15 in. Designs previous to 1919, in general, did not provide a foundation course.

The traffic these roads serve is, for the most part, of a pleasure character and we feel that a 15 in. bituminous macadam road is sufficient to take care of all needs. These roads traverse regions which are not industrial in character and heavy vehicles are infrequent.

During the past year we contracted for the laying of a 40 ft. concrete pavement on the so-called Conduit Boulevard in Nassau County. This is the largest highway contract ever executed by the State, being a little more than 16 miles long and the contract price being nearly $1,400,000. We propose, during the coming season, to award an 8 mile contract for the paving of this same Boulevard in the Counties of Kings and Queens and the work on the entire 24 miles should be completed by the end of the year. When completed, it should tremendously relieve the present traffic on the Queens Boulevard in Queens Borough and the Merrick Road in Nassau County, which are now so badly congested.

Traffic Lanes to be 10 ft. Wide.—A change in design which I believe will interest you is that the Department now considers necessary in the interest of safety and convenience the construction of traffic lanes 10 ft. in width rather than as heretofore, 9 ft. in width. Thus, on the main route, Albany to New York, all new construction is on the basis of 30 ft. minimum width of pavement as against the former standard 27 ft. width and on the east side of the Hudson River, the entire length of this route has been reconstructed or placed under contract for reconstruction with a minimum width of 27 ft. with a considerable mileage of 36 and 40 ft. width near important centers of population. In our operations we have spent large sums to improve alignment and grade and in some cases, we have so relocated the highway as to avoid entirely centers of population which cause congestion of and delay to traffic. In the not distant future, we expect to have completed and in first class condition two routes, New York to Buffalo via Albany with minimum width of pavement of 30 ft. traversing the wealthiest and most active industrial sections of the Empire State.

When we consider the width of pavements now under construction and the moneys being spent therefor at the present time, we are compelled to admit that the man who discussed intelligently these subjects a few years ago and who was considered visionary and a dreamer was really the man with foresight who had the right idea.

Who can foresee and foretell the future?

Acknowledgment.—The above is an abstract of an address presented March 15, before the New York State Highway Chapter of the Associated General Contractors of America.

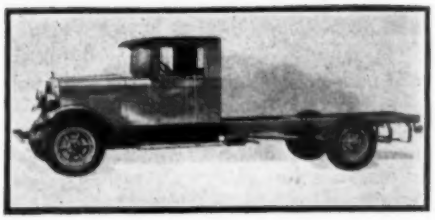
Indiana Announces a New Model Truck

A new 2-ton, 6-cylinder chassis has been added to the line of motor trucks manufactured by the Indiana Truck Corporation, Marion, Indiana. It is known as the "Admiral"—Model 400, and has proved worth while in performance, mechanical design, and flexibility both in quick getaway and ability for fast road speeds, according to the manufacturers.

This new Indiana model has mechanical 4-wheel brakes, 4-speed transmission, and is powered by a 6-cylinder engine with a 75 brake h.p. rating. The chassis is available in 157-in. and 175-in. wheelbase lengths.

The patented "Tors-Elim" 3-point suspension mounting of motor and radiator units (exclusive to Indiana trucks) is used on the Indiana Admiral chassis. When cam is specified (extra equipment) it comes with the "Tors-Elim" mounting—this is the Indiana DeLuxe cab with 3-point mounting, equipped with full length doors with sliding glass windows, operated by crank, and is built with an all metal roof covered with a durable fabric.

Indiana "Tors-Elim" 3-point suspension mounting provides a suitable support for the radiator, hood, cowl and cab with respect to the frame. It frees



New Truck Chassis Produced by Indiana Truck Corporation

the radiator, hood, cowl and cab from any torsional strain and vibration, to which the chassis is always subjected, say the builders, and this prolongs the life of the truck and adds to easy riding qualities. "Tors-Elim" 3-point suspension mounting maintains and keeps the radiator, hood, cowl and cab from being affected in any way, regardless of the torsional strain imposed upon the chassis, and these units maintain their position substantially as a single unit independently of the chassis.

This new mounting, it is claimed, eliminates the constant punishment ordinarily received by the radiator, due to the constant twisting of the chassis. One of the most important advantages claimed with this new radiator mounting is the improvement in the steering at high speeds. By severing the rigid relation of the radiator to the front axle asembly, the synchronizing of the radiator and hood with the vibration or tramp of the front axle assembly at high speeds over uneven or rough roads has been eliminated, it is said. With the new hood mounting in the "Tors-Elim" 3-point suspension there is no movement of the hood in relation to the cab or radiator, thereby preventing hood squeaks, wearing out of hood lacing, and marring finish on cowl of cab and radiator. The gasoline tank is under the seat of the cab, also on a 3-point mounting, freeing it from extreme twists of the frame.

Standard equipment on the Indiana Admiral includes Moto-Meter, full crown front fenders and running boards, nickel plated spring bumper, electric starting and lighting equipment, Tilt-ray headlights, electric horn, dash light, air cleaner, oil filtrator, speedometer and tire carrier.

Unit Prices on Federal Aid Work in Wisconsin

The following comparison of the unit prices on Federal Aid road work in Wisconsin is taken from the fourth quarterly report for 1927 of H. J. Kuelling, state highway engineer of Wisconsin:

Comparison of Federal Aid Unit Prices

Excavation:	1926	1927
Earth, cu. yd.	$0.522	$0.4705
Borrow, cu. yd.	0.445	0.4603
Loose Rock, cu. yd.	1.07	0.8105
Solid Rock, cu. yd.	1.77	1.739
Concrete in Culverts, cu. yd.	24.32	24.30
Concrete in Bridges, cu. yd.	27.20	25.25
Concrete Paving, cu. yd.	1.936	1.986
Type A Guard Rail, lin. ft.	0.606	0.637
Type C Guard Rail, post	1.11	1.194
Crushed Stone in Place, cu. yd.	2.14	2.43
Gravel in Place, cu. yd.	1.91	.....
Gravel in Bins at Plant, cu. yd.	.....	0.975

The Study of Concrete Pavement From Core Drill Records

What a Study of Specimens from Concrete Roads Shows

By C. E. FOSTER
Construction Engineer, Michigan State Highway Department, Lansing, Mich.

THERE is no subject of more interest to the highway engineer today than the manufacture of concrete. Engineers from all branches of the profession are more fully awake than ever to the necessity of producing the very best concrete possible with the materials at hand. In this state during the past year approximately 70 per cent of all the roads built on trunk line and Federal aid routes had this material as the principal constituent of the metal. For the reason that this material is in such general use for road surfaces no source of information should be left unexplored which might add to the knowledge of its use.

Factors of Successful Construction.—In order to lead logically up to the subject in hand, it might be well to digress for a moment and mention a few of the factors involved in the successful construction of a concrete pavement. For first consideration is the matter of subgrade, which will not be discussed except to state that a subgrade for a rigid pavement should receive the greatest of attention in order that an even support be provided for the slab. Next comes the design of the slab—thickness, joint spacing, reinforcement, etc. Much progress has been made during the past few years in design of concrete slabs, but very little that is new has been developed just recently. In fact, pavement design is practically at a standstill and will likely remain so until such time as soil and pavement surveys have been completed and correlated so that new data concerning the behavior of various designs under varying conditions of soil, traffic and climate may be used for more rational design.

The third factor, and the one which most of us come more closely in contact with than the first two mentioned, has to do entirely with the quality of the work performed in the field. The quality of concrete secured on any job depends, first, upon satisfactory materials, second, upon proper construction methods and, third, upon successful utilization of men and the direction of their efforts toward first class workmanship. These three factors—subgrade, slab design and workmanship are vital and fundamental and no one of them may be slighted, in the least degree, if the most satisfactory results possible are to be otbained.

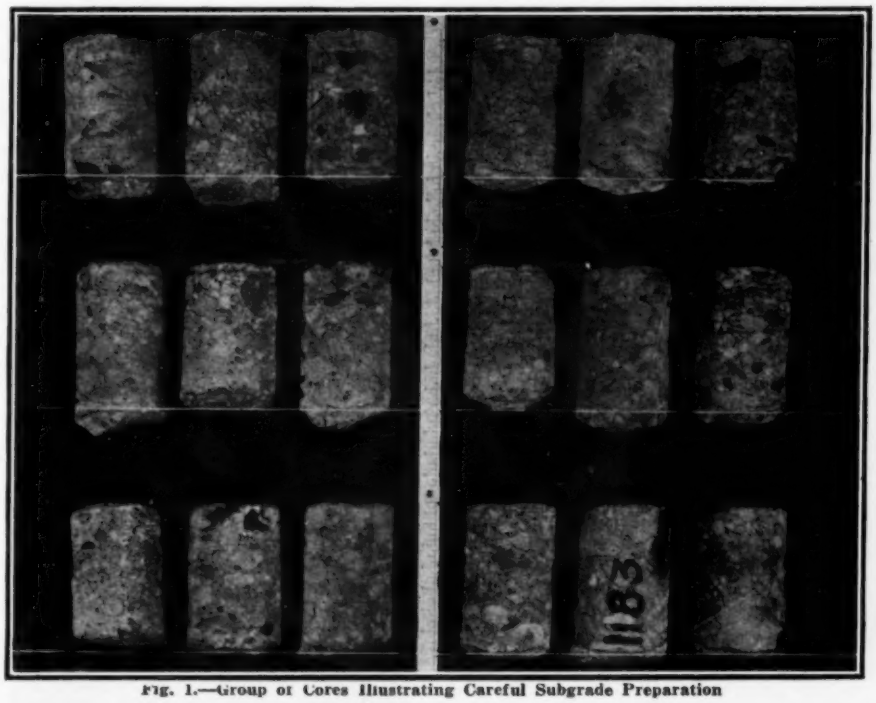


Fig. 1.—Group of Cores Illustrating Careful Subgrade Preparation

Fig. 2.—Group of Cores Illustrating Poor Subgrade Preparation

The subject, "The Study of Concrete Pavement from Core Drill Records" is limited in scope, having to do principally with the quality of the work performed. However, the information secured from the study of specimens taken from concrete roads will be ma-

Fig. 3.—Cores Showing Porous Mortar

terially beneficial, if future performance of concrete pavement under traffic can be improved by the study of these records.

The Core Drill Outfit, and Reports.—The State Highway Department began to core-drill pavements in 1922, the object being to determine whether or not proper thickness of slab was being secured. Since that time, one and sometimes two core drill outfite have been operated during the greater part of each construction season. The equipment itself consists of a shot drill mounted on a truck. The principal items of the drilling outfit are a gasoline engine which operates a vertical shaft through a clutch mechanism to which is attached a cutting head. The cutting head is equipped with a hollow cylindrical cutting bit which, when rotated on the pavement with chilled steel shot as an abrasive, cuts out a core 4¼ in. in diameter for the full depth of the pavement. It takes from one-half hour to one hour to take a core from the road, depending upon the age of the specimen and the quality of the concrete. The cost of the operation is approximately $35 per day, including the rental of truck and drill; supplies, such as gasoline, oil, shot, etc., and the salary and expenses of the operator and helper.

The organization and routine reports are very simple. The operations of the core drill equipment are regulated from the central office at Lansing. At the beginning of the season an itinerary is laid out for the outfit, so that the various jobs may be core drilled with a minimum amount of travel between jobs and as soon after the actual placing of the pavement as is practicable. It is important that the cores be drilled soon after the placing of the pavement, since final estimates on paving projects are not paid until the thickness of the pavement has been determined by core drilling. The operator sends a daily report to the central office on which is shown the number of cores drilled, their locations, their condition, and their depths. With these reports at hand it is a simple matter to tabulate the data and show just how the job has been handled. This data is especially valuable when it is possible to core drill completed portions of projects on which paving is still in progress, because there is then an opportunity, in case of variation in the thickness, to see that the new work is paced properly.

Original Purpose in Core Drilling.—As previously stated, the original object in core drilling was to determine the thickness of the pavement placed. In 1922 it was more of an object for a dishonest contractor to skimp on thickness of slab than it is at the present time, because at that time the contractors furnished the cement, which is the most expensive single ingredient going into the manufacture of concrete and which it was a supposed virtue by some to save, if possible. Since that time, however, the state has adopted the policy of purchasing and furnishing the cement—thus the incentive, on

Fig. 4.—Core Showing Segregation

the part of a contractor to save this material has been eliminated. However, there are very few highway contractors who are actually dishonest, that is, those who deliberately try to skin a job. There has been a decided improvement in the road building industry along this line brought about during the past few years by a change in attitude on the part of both contractors and engineers—the former adopting better business practice in their work and the latter improving their specifications so that the work to be done is more clearly defined. But engineers still have to contend with carelessness and lack of knowledge of what is required on even the best managed jobs. It must be borne in mind that the construction of a concrete pavement involves the use of a large number of men arranged into an organization. The organization must work with speed or lose money. Under these conditions, carelessness in performing vital functions, affecting the life of the completed work, may easily become general and be fully as detrimental as premediated crookedness. This is true in the face of the fact that the contractor may have the best of intentions.

When core drilling was first attempted it was intended to eliminate thin pavement from our construction work. The results have been good, but occasionally a job is found that has gotten out of control, and, in cases of this kind, both contractor and engineer must be dealt with sternly. The specifications which govern thin pavement follow.

"Tolerances in Thickness of Pavement."—The pavement shall be constructed strictly in accordance with the dimensions shown on the plans. If proper methods are employed and reasonable care taken, the thickness should not vary more than ½ in. from the thickness shown on the plans. Variations greater than this will be considered due to poor workmanship and the following rules will govern relative to replacing and paying for pavement not built in accordance with the plan dimensions:

(1) Sections of pavement deficient in thickness more than 1 in. shall be removed and replaced by the contractor, at his expense, with pavement of the specified thickness, and the cost of the cement which was used in the section to be removed will be deducted from estimates to the contractor the same as spoiled cement.

(2) When the average thickness of the pavement, exclusive of those sections more than 1 in. deficient in thickness, is less than the thickness shown on the plans, the unit price for payment shall bear the same proportion to the contract unit price as the square of the average thickness of the pavement constructed bears to the square of the thickness as shown on the plans.

"The thickness of the pavement will be determined by measuring the length of cores drilled from it. At least one core will be drilled within the limits of each 1,056 lin. ft. of pavement, at such point as the engineer may select. The average thickness will be determined for each mile of pavement, and the fraction of a mile when the contract is of such length that it cannot be divided into an integral number of miles. A unit price for each mile and frac-

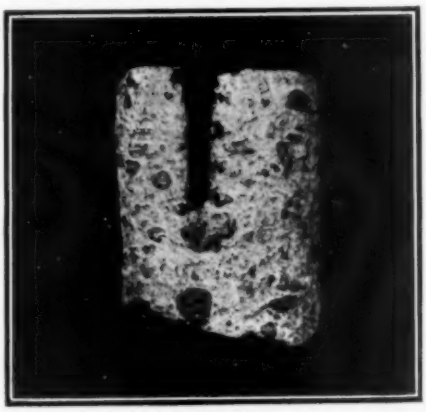


Fig. 5.—Core Showing Formed Center Joint

tion of a mile will be determined as specified above, and such unit price will be used as the basis of payment.

"The average thickness of the pavement shall be considered as the average of the lengths of the first core drilled from each 1,056 ft. section, except that no length of core greater than the thickness shown on the plans plus ½ in. and no length of core less than the thickness shown on the plans minus 1 in. will be included in the average."

The Cost of Excess Thickness.—The contratcor is furnished with a copy of the core record of his job and aside from the penalty of thin pavement, there is a lesson which he may learn from a study of this record, if he but cares to go into the matter. For instance, suppose the average thickness of the cores is ½ in. in excess of the plan requirement of 7 in. The extra thickness figures slightly over 7 per cent of the thickness required. This percentage translated into extra materials and labor of placing is certainly not less than 5 per cent of the cost of the slab. The cost of this extra thickness is dependent upon the unit cost of the pavement placed, but a safe figure would be 5 or 6 cents per square yard, and amounts to approximately $600 per mile. The extra labor required to make the subgrade perfect should not exceed one-tenth of this sum.

Illustrations of Careful and Careless Subgrade Preparation.—In illustration of the foregoing remarks in regard to subgrade construction, Fig. 1 is a photograph of a group of cores taken from a project on which it is evident that very careful subgrade control was maintained. Fig. 2 illustrates what may be expected when very little, if any, care is taken in the preparation of the subgrade. The top of the cores in these illustrations is the surface of the pavement and the white line across the bottom of the cores represents plan thickness of pavement.

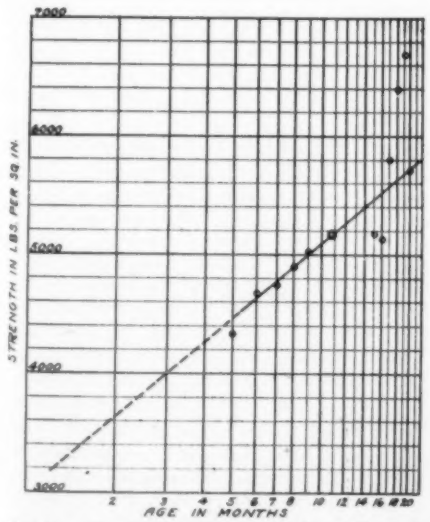


Fig. 7.—Average Strength of All Cores Crushed During 1926

Concluding the part of this study having to do with pavement thickness, it is obvious from the examples shown that it cannot be taken for granted that a uniform thickness of pavement will be obtained unless adequate and intelligent inspection is provided. When it is found that wide variations in pavement thickness exist, it must be borne in mind that the owner, whether state, county or city, had full power under the specifications to stop the faulty construction as it progressed. If this was not done, and the contractor required to proceed daily in accordance with the specifications it must be admitted that the result obtained is a measure of the inspection provided. This fact alone is reason enough for employing only men who are fitted by training, experience, integrity and personality for inspectors at the mixer. It is absolutely impossible for the engineer to be at all points on the job all of the time and, therefore, it is the inspector upon whom falls the responsibility of keeping the engineer informed of the daily operations of the crew during the engineer's absence. Inspectors at the mixer, surely should be well chosen men.

Other Features Shown by Core Studies.—Aside from pavement thickness there are a number of other interesting features which may be studied from sepcial cores taken from the pavement or from the examination of the regular cores, such as segregation, thickness of motor coat, air and water voids, etc. Figs. 3 to 6 inclusive are cases in point.

Thus far all that has been said relative to the study of concrete pavements from core records has been developed entirely from a visual inspection of the specimens. However, the facts which these individual specimens show will be left until the last and the important part of this study has been considered which has to do entirely with the crushing strengths of the specimens.

Tests of Crushing Strengths of Concrete.—Each year since 1922 a few cores from individual projects had been crushed to determine the strength of the concrete. In 1926 a larger number of specimens were tested and the results arranged in such a way that they could be studied. This work was continued on jobs completed during 1927 and the data for both years follows in the form of a series of graphs of which Figs. 7 to 10 inclusive are reproductions.

Fig. 7 shows the average strength of all of the cores crushed during 1926, strength being plotted as abscissae and age plotted as ordinates. It can be noted that the average strengths fall into a fairly regular curve.

Fig. 8 shows the strength of individual cores on a typical project. It can be readily noted that there are large variations in strength of the individual specimens.

Fig. 6.—Cores Showing Steel Center Joint

Fig. 9 shows the strength of individual cores by age selected from several projects for the purpose of studying the strengths of the individual specimens as well as the average strength in the entire age range. The heavy dotted line connects the average strengths at the various ages. The curve showing the average strengths in 1926 (Fig. 7) superimposed on this data indicates a very general conformity to the averages of the previous year. However, the striking thing in connection with this graph is the lack of uniformity of strength between individual specimens.

Fig. 10 is a study of the average strengths of the cores of an average age of 205 days on nineteen different projects. The strength range on these projects should be noted.

What the Strength Charts Show.—This concludes an abstract of the data from which this paper was prepared and is typical of the results secured by crushing cores. Before any conclusions are drawn the facts should be briefly reviewed. First, it has been shown from the strength charts that there is a decided lack of uniformity in the strength of concrete on the individual projects, the difference in strength of individual specimens of the same age being as much as 2,500 lb. per square inch. Second, on some projects it has been shown that the average strength of a group of specimens at two or three months of age is stronger than the average strength of another group of specimens much older. This is contrary to the behavior of carefully controlled laboratory concrete which, under ordinary conditions, grows stronger with age. Third, it has been shown that there is a decided lack of uniformity in the average strength of concrete of the same age on a group of projects, the total range of difference in strength on the projects studied being upwards of 2,800 lb. per square inch. Fourth, visual inspection of the individual cores shows segregation of fine and coarse aggregate, porosity, and other defects.

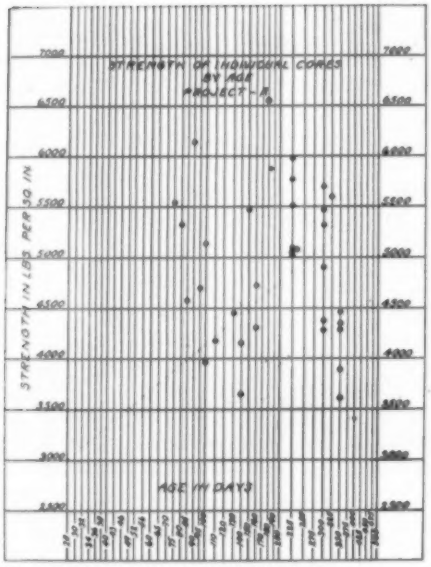


Fig. 8.—Strength of Individual Cores on a Typical Project

When considering these facts it must be remembered that the specimens tested are actual samples taken from the pavement. The crushing strengths, therefore, represent strength of the pavement—barring improper handling of specimens prior to testing and natural errors in capping the cores and testing them. It should also be borne in mind that all of the materials which went into the construction of the pavements represented by these specimens, passed laboratory inspection and met the requirements of our specifications. The construction methods prescribed by the specifications were followed out as near as it is possible for different engineers to interpret the meaning of the specifications and apply the principles to their work. There is, of course, a human element in the application of these construction methods. But from the observation of many jobs in the field, it would appear that the average interpretation of these methods has been well within the intent of the specifications.

Granting that these facts are true, it must be admitted that working under the old volumetric specification for proportioning concrete aggregates the strength of the concrete cannot be predicted or controlled unless greater attention is given than heretofore (1) to the segregation of aggregates (2) to the volumetric changes in the aggregate due to the presence of varying quantities of moisture and (3) to the total quantity of water per batch of concrete.

In other words, to secure uniformity of strength on even a single project it must be possible to easily control the amount of fine aggregate, the amount of coarse aggregate, and the amount of water in each batch of concrete. It is possible to correct for varying conditions in aggregate when using the volumetric method of proportioning, but it is admittedly impracticable, since to secure good results, changes in batch size might be required several times daily with consequent delay in operation of plant. It has been demonstrated that weight measurement of aggregates is practicable and flexible and with this method of measurement, fluctuating conditions of aggregate and moisture cause much less disturbance of the total mineral aggregate in each batch. Adjustments in proportions are also easily possible, involving no more labor than is necessary to change the weights on the scale beam.

The 1928 Specifications for Proportioning.—In view of the results of core strength tests, the Michigan State Highway Department specifications for 1928 paving provide for the proportioning of concrete aggregate by weight and accurate measurement of total water content. For the present, the proportions of cement, fine aggregate, and coarse aggregate will be based upon the characteristics of the materials themselves, in combination, such as to develop the maximum strength with a given cement content per cubic yard of finished concrete. Careful studies are being made of all available aggregates and when these are completed and test results of field concrete made over a period of time, advantage may be taken of the data secured to effect economy by designing for a given strength.

Field research will also be conducted on a number of selected jobs for the purpose of determining just what may be expected in the way of uniformity by accurate field control, taking into consideration all of the factors affecting the strength of concrete. Accurate control of proportioning and other field operations will be established and laboratory practice on the job applied to those operations which lend themselves to laboratory methods.

The study of core records also indicates a need for adequate and high grade engineering personnel, equipped to handle both street and plant inspection—fairly, impartially and last, but not least, daily—so that no regrets may be had after it is too late to correct the conditions which may result in unsatisfactory work.

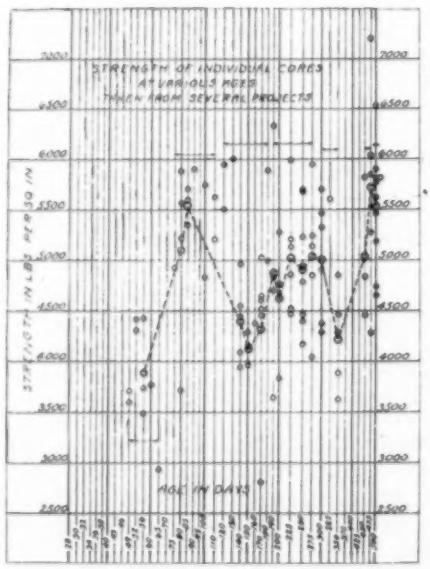


Fig. 9.—Strength of Individual Cores by Age Selected from Several Projects

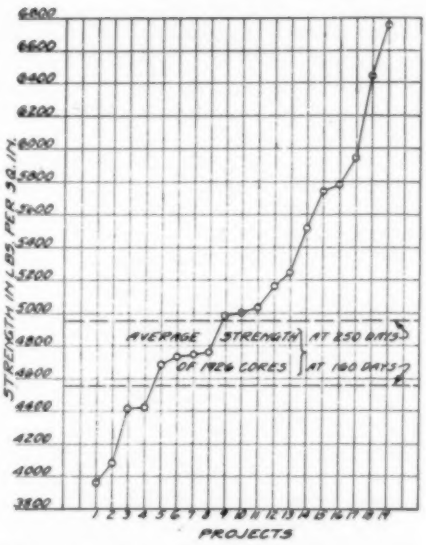


Fig. 10.—Study of Average Strength of Cores of an Average Age of 205 Days on 19 Different Projects

Acknowledgment.—The foregoing is a paper presented at the 1928 Highway Engineering Conference, University of Michigan, Ann Arbor, Mich.

Program for 1929 Convention A. R. B. A. Started

Work on the 1929 program of the annual Convention and Road Show of the American Road Building Association, has been put under way. A change in policy designed to improve the papers to be delivered will be inaugurated for the meeting. C. N. Conner, chief engineer for the association, is already at work on the program. A large portion of the papers to be delivered will be in the nature of committee reports and will combine the experiences of a number of authorities in one treatise, thereby lending added authority and increasing the range of each subject.

Program committees will be named by Col. R. Keith Compton, soon after he becomes president of the association on May 11th.

Highway Transport Congress in Cuba.—Cuba's second highway transport congress, will be held in Havana, Feb. 22-23, 1928, under the auspices of the Camara de Comercio de Automoviles and the Automovile Club de Cuba. General Gerardo Machado, president of Cuba, will be Honorary Chairman of this event. Dr. Carlos Miguel de Cespedes, Secretary of Public Works, will be active Chairman of the Congress.

A Comprehensive Discussion of the Causes of Highway Accidents

Paper Presented at 14th Annual Conference on Highway Engineering U of Michigan

By WILLIAM G. ELIOT, 3d

Associate Highway Economist, U. S. Bureau of Public Roads, Washington, D. C.

LET me say right at the opening of this discussion, to dispel any illusions which you may entertain on the subject, that any scientific knowledge of the causes of highway accidents is still in a highly elementary stage. We all have a general familiarity with highway accidents, and we have probably formed certain opinions of our own as to why they happen. We know that they happen more frequently under certain circumstances than under others, and we have accomplished much in the correction of obviously dangerous conditions. But we are still a long way from any comprehensive and accurate statistical facts as to the absolute or relative importance of the many different factors, which individually or in combination, result in what we call accidents.

No Uniform Definition of Accident.—We have, for example, only a very vague notion as to the frequency with which accidents take place. We do not even have any uniformly accepted definition of an "accident." New York State requires the reporting only of accidents resulting in personal casualties. Connecticut requires the reporting also of all those causing property damage in excess of ten dollars. The statistics of grade crossing accidents, as published by the Interstate Commerce Commission, include only those resulting in personal injuries or in damage to railroad property in excess of $150. Such differences are not highly important, perhaps, since we are primarily interested in the safety of persons, yet there would seem to be no essential distinction to be drawn, from the point of view of causation, between personal injury accidents and those causing property damage only. Complete accident data should logically include all accidents resulting in major property loss, whether or not they involve personal casualties.

Accident Statistics.—We do know, with reasonable accuracy, the total number of deaths resulting from accidents on our streets and highways. According to the National Safety Council (Chicago) this reached a figure of approximately 25,000 during 1926, and was increasing at the rate of 2,000 additional deaths yearly. I have not yet seen any estimates for 1927, but I am not optimistic as to the prospects for great improvement, if any, over the preceeding year.

We have at present no satisfactory estimates of the number of non-fatal injuries received in traffic accidents. Certainly it is very large. From the experience in local areas the statistics committee of the 1926 Hoover Safety Conference estimated that for every person killed at least 25 persons suffer serious non-fatal injuries. We are therefore probably well within the truth in saying that 600,000 persons or more are seriously injured each year, and a great many more suffer minor injuries.

So much for the magnitude of the problem. For our present purposes it is sufficient to know that accidents happen entirely too frequently. We are not so much interested in the exact number of accidents as in the why and how. We have hardly begun to accumulate accident data sufficiently detailed to provide a proper basis for a real study of causes.

The study of highway accidents does not easily lend itself to laboratory methods. We can not well set up experimental conditions with simultaneous "controls," and undertake the successive isolation of the different factors. Accidents manufactured to order are hardly accidents. And they are too costly to play with, even in a good cause, if there is any other procedure possible. We are forced to resort to the method of statistics, the assembling of data from events as they happen, and the subsequent analysis of these data by more or less mathematical processes.

Difficulty in Collecting Evidence.—The major difficulty is to gather the evidence. In the nature of the case, it is necessary to reply principally upon public authorities who administer the streets and highways or who are responsible for the regulation of motor vehicles. In a city the police department is in the strategic position for the investigation and reporting of accidents. With rare exceptions every accident can be promptly reported by the patrolman upon whose beat it occurs. As to the difficulties of securing adequate and accurate reports I shall have more to say in a moment. In rural areas the statistical obstacles are for more serious. The civil jurisdictions are very numerous. Few of them have accidents frequently enough to convince them of the need for systematic accident records, and in few of them are the officials sufficiently interested in the problem to take the extra trouble necessary to maintain such records. A state highway department is sometimes in a position to require reports from its local maintenance men, which will yield valuable data for the limited mileage included in the state highway system, but it is difficult to get adequate records for secondary roads and village streets.

Compulsory Reporting of Accidents.—The compulsory reporting to some central authority of all motor vehicle accidents by those involved in them, as already required in a number of States, offers perhaps the simplest practical means for the accumulation of some sort of comprehensive accident records. The statistics published by Connecticut and New York State illustrate the effectiveness of such a system when carefully administered. Numerous mishaps doubtless escape reporting, but these can be kept to a minimum by checking with independent local police records and even newspaper clippings.

There is another real difficulty, however and that is to secure uniformly complete and intelligent reports. Most highway accidents are the result of complex interrelation of circumstances, some of which are not easily recognized by the untrained observer or by a participant naturally somewhat upset or biased, or both. The reports are therefore apt to be incomplete in some respects and even inaccurate as to the details given. Several means have been used to improve this situation.

Accident Report Forms.—The first is the adoption of a report form. Such a form consists of a card or sheet calling for certain specified information. A detailed list of the common contributing causes and circumstances is included, and the person making the report is instructed to check off those items applying to the accident in question. The element of individual judgment is thus somewhat reduced, and the likelihood of omission of important details materially lessened.

The best known report form is that of the National Safety Council. It has been carefully planned and revised in the light of experience extending over a number of years, and in its essential details is now in use in something over 60 cities and in the State of New York. The widespread use of this uniform reporting system has made it possible to secure a very con-

siderable and worth-while volume of mass evidence relating to traffic accidents, particularly to accidents of an urban type. In fact, the annual accident studies of the National Safety Council are far and away the most valuable general analyses of traffic accident statistics being made anywhere in this country. The most serious fault that one can find in its report form is that in the laudable attempt to secure simplicity there have been omitted certain details which some of us would like to see included—specifically those of a peculiarly rural nature such as road surface, grades, and the like. Fortunately there is nothing in the use of a standard system which prevents the supplementary recording at the same time of any additional data that may be desired for local information. As long as the National Safety Council form is used as the base, all reports from different areas will be comparable at least to the extent of the information called for on that particular form.

Use of Experienced Investigators.—Accurate detail in the reporting of accidents, however, even with a standard report form, calls for experienced investigators who, by specializing in the subject, can learn to analyze the circumstances relating to the accident and to report reliably the causes. The Massachusetts Registrar of Motor Vehicles has for some years employed special investigators to inquire into the causes of all fatal accidents. For a smaller area, but in an eminently effective and thorough way, the Cleveland police department has for more than a year now maintained its "manslaughter squad," whose duty it is promptly to investigate every fatal traffic accident as soon as the report reaches headquarters. Two members of the squad are on duty day and night, ready to hasten to the scene of any accident with complete equipment for securing evidence from witnesses, photographing significant details and taking measurements. A widespread following of such examples, and the extension of equal care to the investigation of the less serious accidents, would be of the greatest value in the intensive study of street and highway hazards.

Highway accidents, as already intimated, are complex things. Few, if any, can be attributed to a single cause, although we are usually inclined to put the blame primarily on one particular factor. While it is exceedingly important that we make an effort to fix responsibility for each accident, in order that we may impose proper legal penalties where necessary, it is just as important that we record all of the circumstances which play any contributory part. Even so-called secondary causes, if present in a large number of instances, may appear to be of primary significance when studied on a larger scale. Furthermore, fixing responsibility usually calls for a nice bit of discriminating judgment, and in statistical studies the basic evidence should be as free as possible from all opportunities for bias.

Complete and Accurate Data Needed.—I have perhaps spent an undue proportion of my time on what is, in a sense, only an introduction to my announced theme. Yet I feel that it is really one of the most important parts of what I have to say. The need for complete and accurate data concerning street and highway accidents is highly urgent if we are to make our safety work anything more than a somewhat haphazard hitting out at local danger spots. The need is particularly great with reference to those accidents which occur on rural highway. Most of the accident statistics which are now available are those for cities, or for areas dominated by large cities. There is good reason for believing that there are fundamental differences between city and country in the kinds of highway accidents and in the relative importance of the causes which bring them about.

Contributory Causes of Accidents.—The causes contributing to highway accidents may be grouped in four more or less distinct categories. These are:

1. Surface, alignment, or other features of the highway.
2. The design or construction of the motor vehicle.
3. The regulation of traffic or the absence of such regulation.
4. Last and most important, the "personal factor."

Most of those causes which are inherent in the road itself are pretty well recognized by everyone. We can hardly hope to make our roads completely fool-proof, but the principal obstacle which hinders our approach to that ideal condition is not that we do not know how to build safe roads, but that we do not have the financial means for doing so. There is no argument as to the theoretical desirability of eliminating railroad grade crossings or of the separation of highway grades at intersections, or of the reduction of horizontal and vertical curvature to a minimum, or of setting culvert walls and other obstructions a safe distance back from the edge of the traveled way, or of providing (within certain limits, at any rate) a pavement wide enough to carry its normal maximum traffic, or of building substantial shoulders for emergency parking, or passing, making the surface skid-proof, or of establishing safe guard rails or fences at the edges of embankments. Every such improvement eliminates some recognized hazardous condition, but all of them are expensive and most of our roads must therefore be compromises. Data as to the relative importance of these different hazards may help us to know where we can best afford to compromise.

Accidents at Grade Crosings.—The railroad grade crossing on our major highways clearly must go. A recent study by the Bureau of Public Roads showed that at least 16 per cent of the accidental fatalities on the rural highways of the country occurred at the steam railroad crossings. In 1926 Michigan ranked sixth among the states in the number of its grade-crossing accidents, there being approximately 130 persons killed in some 350 accidents. I doubt if grade crossings can ever be made safe, but as long as we have them with us—which will be a long time yet—we can by adequate protection do much to make them less dangerous. The most important need is for the wider use of automatic, train controlling crossing signals, especially in the rural areas where most of the crossings are now unprotected, and for the improving of visibility at all crossings so that those approaching on the highway can get a good view of any train in ample time to stop.

Dangers at Rural Highway Intersections.—With increasing highway speeds the rural highway intersection takes on some of the characteristics of the railroad crossing. Unlike the railroad train, however, the automobile can, and usually does, slacken speed at intersections and is under far more flexible control. Pavements should be widened adjacent to intersections to allow additional space for turning and passing, and, where practicable, buildings, trees and other obstructions to a clear view should be removed to a safe distance. Where highways are of differing importance one of them may be designated as "arterial," and intersecting traffic be compelled to give right of way. Certainly the "Stop, Look and Listen" rule should be enforced wherever a private road enters a public highway. In rare instances outside of the cities, "Stop and Go" lights may be needed. The separation of highway grades is justified only where the traffic on both roads is very heavy, or where either one of them is designed as a high-speed express route.

The fact that statistics from several states show more accidents happening on highway tangents than on curves does not prove that tangents are more dangerous than curves, in view of the far greater mileage of tangents. It does suggest the possible advisability of some sort of speed control on the tempting straight stretches. A prominent highway official recently went so far as to suggest that gentle curves in a highway might be desirable as a means of keeping drivers alert and to prevent them from indulging in too great a speed.

Warning Signs.—Proper warning signs at points of special hazard, and the absence of all unnecessary and confusing signs are rightfully regarded as essential features of an improved highway system. The recent adoption of nationally standardized warning and caution signs by the Association of State Highway Officials, and the installation of these signs which has already

followed rapidly in many states, have marked an important in reducing the element of "the unexpected" along the highways.

Accidents from Motor Vehicle Defects.—Accidents resulting from defects in the mechanism or equipment of the motor vehicle are relatively rare, and are probably of decreasing importance. The National Safety Council estimates them at less than 5 per cent of the total. In Connecticut for the past several years the figure has been given as less than 4 per cent, and in New York State during 1926 of all the vehicles involved in accidents only slightly over 4 per cent were reported as having defective equipment. Such statistics, however, appear to me to be of somewhat doubtful value. In New York the cases of defective brakes are barely 60 per cent greater than those of defective steering gear, while in Connecticut, where only the primary cause of each accident is tabulated, the cases attributed to defective steering gear actually outnumbered those due to defective brakes by over 50 per cent during 1924 and 1925, and by a very small margin in 1926. These proportions simply do not look reasonable to me. The need of more careful investigation of accidents and more adequate reporting of all contributing causes is apparent.

The perfection of the automobile mechanism lies in the hands of the manufacturers, with who self-interest has been the constant urge toward research and improvement. The two principal unsolved problems appear to be headlights and brakes. We still need a headlight which will give adequate illumination of the road ahead without dazzling opposing drivers. I am not sure that the two requirements are not mutually incompatible, and that we may not have to resort to artificial illumination of at least the more important highways. Our need in brakes is not so much for more efficient deceleration—you can almost make a car "nose over" these days—but for mechanism which will not easily become out of adjustment and which can be kept in safe condition by the average owner or service mechanic.

Street and Highway Regulations.—Street and highway regulations are designed to achieve a more orderly, safe and expeditious movement of traffic. The widely varying conditions in different parts of the country and on different roads in the same sections of the country require an adaptation of the regulations to fit the circumstances, but underlying all such variation there should be a foundamental uniformity of all codes so that the traveler is not likely to do the wrong thing through force of habit or through misunderstanding a familiar-looking signal.

Regulation can be overdone, for the ordinary citizen of this free country objects to unnecessary infringement upon his personal liberty and from disregarding useless rules he easily becomes habituated to a contempt for all rules. I may cite the grade-crossing "Stop" laws, which give no recognition to the differing degrees of danger at different crossings. The corollary, however, is that when regulations are once made they must be positively and impartially enforced until experience shows the advisability of changing them.

Speed Regulations.—The state of Michigan has earned wide publicity for its pioneer action in discarding any legally defined speed limit, and it is freely predicted that other states will follow its example in the near future. Yet I dare say that even in this conference there are those who will prefer to watch the experiment for some time before committing themselves in its favor.

I think that I am safe in saying that just now speed is the most controversial question in the whole field of highway safety. On the one hand there are those who insist that the fast automobile operator is a menace to everybody, including himself. There has even been a vigorous, and apparently successful, protest against the advertising of high potential speeds for motor cars. On the other hand are those who argue with equal earnestness that speed in itself is not a cause of accidents and is not necessarily unsafe. Some go so far as to assert that it is the slow driver and not the fast one who is the real cause of dangerous conditions.

Most of the measures adopted in behalf of greater highway safety are incidentally or primarily means for expediting the movement of traffic. They therefore meet with general approval, though there may be some difference of opinion as to details of accomplishment or as to financial feasibility. Any restraints upon vehicle speeds, however, appear to have just the opposite effect, and run directly counter to our American craving to get somewhere in a hurry. It is this conflict between the two interests speed and safety, I believe, which is principally responsible not only for the opposing opinions held by different individuals, but also for the confused and contradictory arguments advanced by either side. Before we can get very far in discussing the question we must get away from hazy generalities and juggling with terms.

Speed and Safety.—We must distinguish between the expediting of traffic by well-planned traffic control or by the building of adequate highways, and that achieved by the speeding up of individual vehicles in the absence of such safeguards. Advocates of higher speeds are constantly referring to notable examples of accelerated traffic with increased safety, such as that on Michigan Boulevard in Chicago, when the progressive traffic lights were installed, or on the "super-highways" out of Detroit, or to the high speed possible on some of the newer portions of our modern highway system. But these are really special cases, and may fairly be called the exceptions that prove the rule, for if they demonstrate anything it is that fundamental changes in conditions are necessary to safe increases in speed, not merely the removal of such an artificial restraint as a legal speed limit.

Importance of Eliminating Causes of Congestion.—We must also discard the fallacious syllogism that congestion causes accidents, increased speed relieves congestion, therefore increased speed will lessen the number of accidents. The principal weakness in this reasoning lies in the assumption that congestion is due to slow speed. It is far nearer the truth to say that slow speed is due to congestion, and that the relief of congestion makes higher speed possible with safety. Generally speaking accidents on congested streets or highways occur either because other vehicles or pedestrians try to cut across the traffic stream, in which case higher speed will only increase the danger, or because certain drivers get impatient and fail to stay in their place in line. Where a roadway is inadequate to permit a segregation of fast and slow traffic, a slow vehicle can cause serious delays. It may be necessary on certain roads and at certain times to restrict or prohibit the use of slow vehicles as a temporary expedient until we can provide sufficient highway capacity. But it is the elimination of the causes of congestion that makes possible an acceleration of traffic, and not the reverse. Furthermore, we have no certain evidence that more vehicles can actually pass a given point at high speed than at low speeds. The much greater headway necessary between fast-moving vehicles may, within certain ranges of speed, neutralize the advantages gained from higher speed. As yet, we have no satisfactory experimental data bearing on this point.

No Critical Speed.—Reckless driving is not always fast driving, nor is slow driving always safe driving. There is no critical speed below which, under any and all circumstances, it is safe, and above which it is always dangerous to travel. That is obvious to anyone, yet some of the protagonists of faster driving assume that a speed limit is supposed to represent such a critical speed, and then with great ease proceed to demolish the "straw man" which they have set up. When they reach their "Q. E. D." they apparently believe that they have convincingly shown the absurdity of any and all speed limits.

The only valid justification or excuse for limiting the speed of ordinary passenger vehicles on the highways must be a belief that the public safety is promoted thereby. If speed in itself is not dangerous, then a speed limit is only a hindrance to quick and easy transportation. If, on the other hand, we admit that speed does increase the hazards of driving, then we must ad-

mit the possible desirability of setting some arbitrary limit on speed.

High Speed a Cause of Accidents.—High speed is unquestionably a cause of accidents, and where it is not a primary cause it is a very important factory in determining the degree of resulting damage. It is a mere quibble to assert that it is recklessness and not speed as such that causes accidents, for there are times and circumstances when recklessness is synonymous with and can be defined only in terms of speed.

We do not know how many persons drive at a speed of less than, say, 40 miles an hour on rural highways because that is the speed limit, and how many do so because they do not believe it safe to drive faster. We do not know how many habitually disregard the speed regulations, and to what degree. We have no data as to the speed of cars involved in rural accidents, especially as to how many of them were traveling in excess of the legal limit. If we could show that very few cars having accidents were "speeding" at the time, that fact might only indicate that the speed laws were being well observed. In other words, we know very little about the relation between speed, speed limits and highway occidents, and the sooner we can dig up some real evidence bearing on the subject the sooner we can come to some sort of intelligent opinion as to the proper policy. Under present conditions speed laws are so varied and so irregularly enforced that we do not know just where we stand. I trust that the Michigan experiment may help to enlighten us.

The Personal Factor.—Of all the causes of highway accidents the hardest to deal with is that which, for lack of a better name, I have termed the "personal factor." I refer particularly to the operator of the motor vehicle, but I have in mind also the pedestrian and other users of the highway. The careless or stupid person can easily nullify all that has been done for his protection and that of the public. The careful and alert person is rarely even the victim of the carelessness of others.

The operator of a motor cycle has under his control, or supposedly under his control, a fast, powerful and dangerous instrument. His use of it is not restricted to any particular place or circumstances. Driving soon becomes habitual and almost subconscious, but it can never become a matter of repetitious routine. The operator must have certain qualifications of a rather high order. He must have, beside the elementary knowledge of how to start, guide and stop his car, an elaborate co-ordination of physical and nervous traits. He must be alert and cool, responding instantly but without confusion to any situation that may arise. He must have a quick and accurate judgment of distances and relative speeds of his own and other vehicles. He must know and obey the rules of the road so that others may depend on his doing the expected thing. Even a moral element plays its part, for an individual may have every other qualification of a good driver and yet show a conscious and willful disregard of the written and unwritten rules of safety.

Driving on our streets and highways today are men, women and perhaps children who tomorrow are to be responsible for some of the seventy deaths which statistics tell us will result from the day's traffic. There are others who will be lucky tomorrow but whose fatal opportunity will come the next day or the day after that. Is there no way to forestall this by identifying and eliminating these drivers in advance of the tragedies?

Licensing Motor Vehicle Operators.—The laws of a majority of the states require motor vehicle operators to be licensed provide the most effective means for keeping dangerous drivers off the roads once we can discover who they are.

Some of the undesirables give themselves away by flagrant public demonstration of their incompetence, in which cases the damage is too often irreparably done before the antidote can be administered. Others will be revealed through an examination imposed on all applicants for licenses. Such an advance test can weed out at least the most evidently unfit, those who can not demonstrate their ability to control a car in ordinary traffic, those who do not know the traffic code, those under age, etc. There are serious practical obstacles in the way of going much farther than this. The more detailed the tests are made, the greater the difficulty of administering them accurately and fairly. Granted that we could infallibly discover all who were below a definite standard, that standard could not be set too high without becoming an unwarranted restriction on the general use of automobiles, which are now so essential a feature of our business and social activity.

The "personal factor," because it is made up of the intangible stuff of human nerves and emotions, cannot be remodeled to order, as can the purely physical aspects of the highway or the mechanism of a vehicle. Persistent and intensive educational safety campaigns, especially among groups of employed chauffeurs and in the public schools have proved demonstrably effective in encouraging caution and increasing the sense of personal responsibility. But, says the pessimist, with considerable justification, you can't change human nature, and accidents continue to happen.

I do not, therefore, see the complete elimination of accidents in the predictable future. I do see a continued improvement in our highways and in the control of traffic on those highways which shall steadily lessen the opportunity or excuse for accidents.

New Type of Toll Road for Alberta

A bill incorporating the Alberta Trackways and authorizing the construction of a 20 ft. wide concrete highway, on which "fares" will be charged to automobiles from Calgary to Banff, Calgary and the international boundary, and Calgary and Edmonton, has been passed by the Railway Committee and is now being considered in the Alberta Legislature, according to a report from Consul Samuel C. Reat, released by the Department of Commerce. If the bill be passed, it is expected that the construction of the concrete highway that is proposed will be completed by 1930.

A report signed by engineers on the estimated cost per mile between Calgary and Banff gives the preliminary estimate from $35,000 to $45,000 per mile. The latter figure will cover the construction of necessary bridges and other costs.

Whether the $2,500,000 of bonds to cover the cost of the Calgary-Banff section would be underwritten in a block by some Canadian agency or whether they would be disposed of to the public at large in Canada and the United States has not yet been determined. The rates would be under the supervision of the Public Utility Board and the proposed concrete highways are in a territory served also by good gravel roads of the government.

According to the proponents of the scheme the concrete trackways will be eliminated from the classification of toll roads, as users would not be compelled to travel on them unless they desired to get the extra service provided by a concrete road by paying the "fare" instead of using the free government road.

Road Construction in the Philippines.—In 1927, 290 kilometers of first class roads and 269 kilometers of second class roads were added to existing highways, bringing the total mileage of first, second and third class roads up to 7,105. The road building program of 1928 contemplates insular government aid to seven inter-provincial and seven provincial roads in Mindanao, connecting the principal provincial roads in Pampanga into concrete, asphalt treatment of considerable mileage of less important Pampanga roads, and the expenditure of some 5,000,000 pesos (approximately $2,500,000) available from insular and provincial sources for road maintenance throughout the islands.

Extra Cement in Mix Opens Road in Four Days After Finishing

Main Highway Paved With Minimum Traffic Delay By Using Rich Mix

WESTERN AVENUE, a broad highway making the city of Chicago, accessible from the eastern parts of the state and from points in Indiana, and one widely used by north and south bound tourists as well as by the weekend drivers residing in that city, is being developed by city, county, and state into what might be eventually called a super-highway, Aside from the current widening and repaving program carried on during the past few years by the city, the portion of the highway outside this jurisdiction and in Cook County is being repaved by the State of Illinois, in cooperation with the County.

Because of the heavy traffic using this highway, from which there are no possible convenient detours, the repaving of a section of the highway 1¾ miles long, south of Blue Island, had to be done in such a way that delay to traffic would be minimized. This work is now under way, with State and County funds, and is being advanced at a good rate.

The job under construction consisted of about 1¾ miles of concrete pavement, constructed according to the standard state section, in two 20 ft. strips, or a total width of 40 ft. The section of each strip consists of a 9 in. edge 1 ft. wide, and then the thickness decreases to 7 in. in 2 ft., and this 7 in. thickness is maintained to the center line of the 20 ft. strip, where a steel parting strip is inserted to form a joint. When the road is to be paved to a width of 40 ft., as on this job, two 20 ft. sections are laid side by side, separated at the center line of the road by a third parting strip, giving a thickened edge on each side of the road and a thickened center line, with preformed joints spaced to split the pavement into four 10 ft. strips. A reinforcing bar is centrally placed in each thickened edge, using metal chairs. To get the standard crown, the finishing machine is set for a 1 in. crown and the outer form is dropped 4 in., to give the desired standard 40 ft. section the right cross section with a 4 in. crown. This design is shown in Fig. 1.

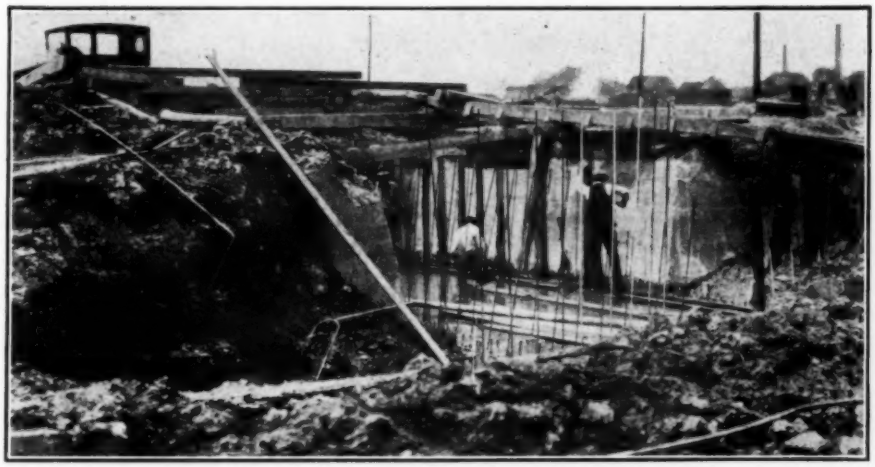


Fig. 2—View of Culvert Construction with One Side Completed and Under Road Carrying Traffic.

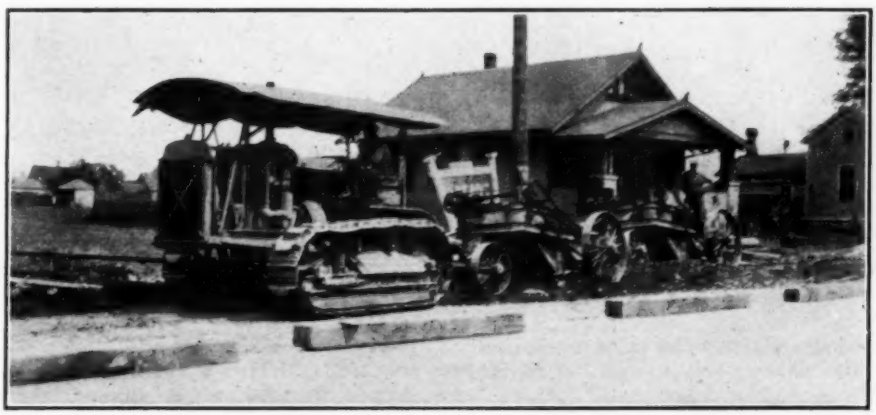


Fig. 3—Grading Operations with Maneys.

Removing Old Work.—The first step in paving this stretch of highway was the removal of existing structures, pavement, and street railway tracks. The length of this street railway line that had to be removed was 1¼ mile, and was double tracked. Over the same length, an 18 ft. concrete and brick pavement, with the brick embedded in the concrete base, had to be broken up and removed. Over the remaining half mile, an old 18 ft. concrete road had to be likewise broken up and removed. To remove the old tracks, a 1 yd. Marion gas-electric shovel was used to raise a section and drop it, and then to pick up the pieces. If the raising and dropping did not jar the ties loose from the rails, a second drop was made, or a 1 ton steel ball was dropped by crane from a height of 25 ft. Rails were laid along the way and ties were piled conveniently. This operation took three 8-hour shifts. Another three 8-hour shrifts were required to load the material into motor trucks and haul

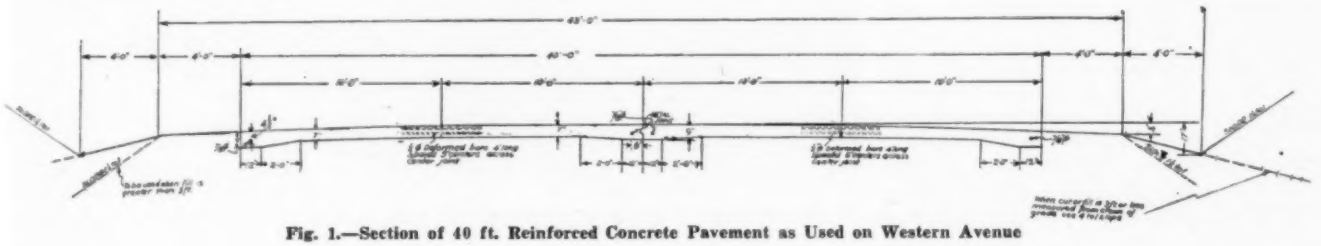


Fig. 1.—Section of 40 ft. Reinforced Concrete Pavement as Used on Western Avenue

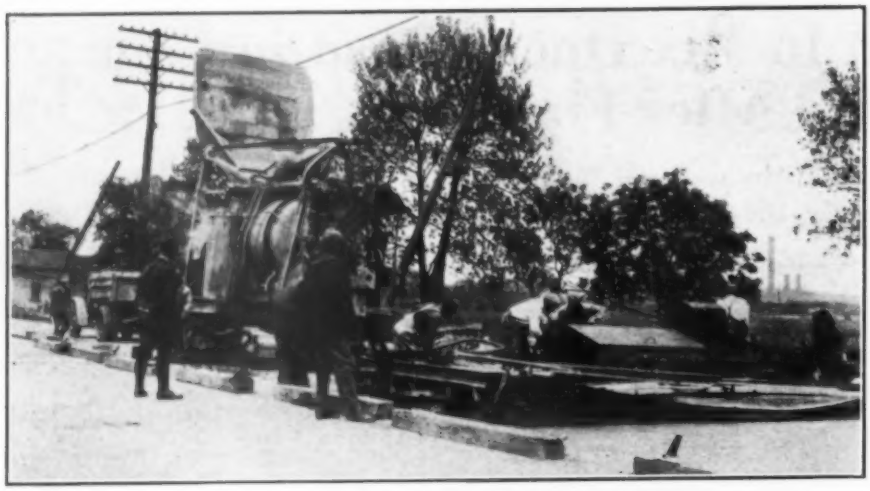


Fig. 4.—The Paving Gang and the Finishers at Work

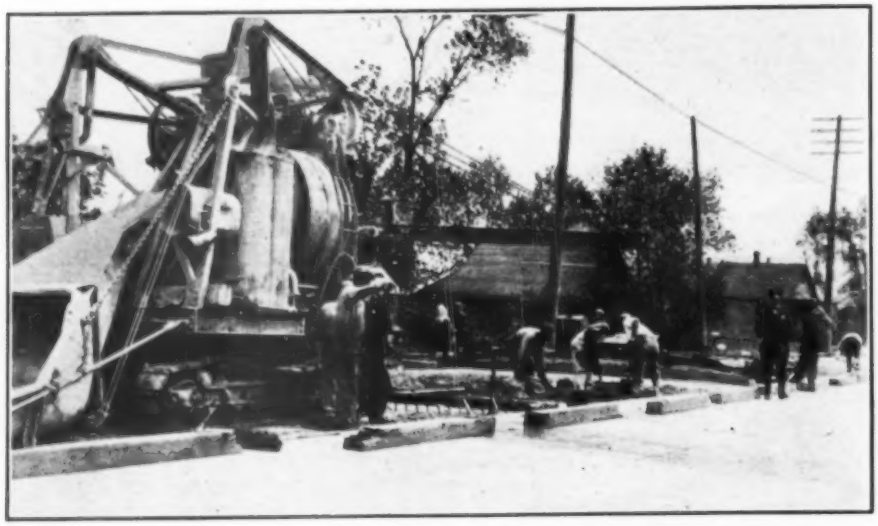


Fig. 5.—Another View of the Paving Operation. Note the Use of Old Railroad Ties as a Guard Against Traffic

away. Enough ties were retained along the right of way to serve as baricades.

The old pavement was first broken up by means of the steel ball, and then loaded into motor trucks by means of the gas-electric shovel. This old slab, laid in 10 ft. widths in 1916, and consisting of 5 in. of concrete base and 4 in. paving brick laid in the concrete, could be broken up and removed at the rate of 800 to 1,000 lin. ft. in an 8½ hour shift. Some reinforcing was encountered. Old culverts were broken up and removed in the same manner.

Rough Grading.—Rough grading was also done with this shovel, loading into trucks, although the amount of rough grading that proved necessary was not excessive except for filling up old ditches, filling at new structures, and similar work.

Final Grading.—The final grading was done in several stages. First, a Caterpillar 60 tractor was hitched to a string of two 1½ yd. Baker Maney self loading scrapers working with a loop of about 600 ft., thus moving theoretically, about 3 yd. of dirt in 5 to 6 minutes. The dirt was stiff clay. This was followed by a shaping with an Adams leaning wheel grader, some fresno work, and rolling with a light roller. This roller was equipped with scarifier and was used to loosen the dirt for the Maneys. Final grade was secured with a Hug subgrading machine.

Delivery Equipment.—The aggregates are loaded in measured amounts into 3-batch Bug trucks at the quarry about 10 miles away. There are 18 of these trucks used, and these deliver the batches to the paver. Cement is hauled by trailer from the cement plant at Buffington, Ind., about 15 miles away, and the load is posted near the mixer at a point where the batch trucks will pass with each load. As the trucks pass this cement trailer, the required cement is dumped on the batch and the truck proceeds to the paver on the subgrade. By securing cement in this manner, at a delivery cost of 13 ct., the charge of 27 ct. for freight is saved, as well as a rehandling cost of about 20 ct. A supply sufficient for a day's run is kept on hand, so that the cost of stored materials is minimized, and loss through storm damage is minimized as well. The cement for this job is supplied by the State. Reinforcing steel and other materials are likewise delivered by truck and distributed along the job for use.

Paving Equipment.—The paver used on the job is a 27-E Koehring, and this is served in the usual way by the motor trucks, and discharges the mix onto the subgrade. The crew at the mixer includes the following men:

1 Operator.
1 Finishing Machine Operator.
4 Shovel men.
1 Steel laborer.
2 Laborers on subgrade.
1 Dumper.

Steel is set just ahead of the concrete, and as fast as the concrete is spread the Ord finishing machine is put to work finishing the slab. Behind this work two finishers with floats who perfect the surface.

Curing.—As rapidly as the surface is finished it is covered with a layer of burlap and this layer is left on until the next morning. Four men are needed part time for this operation. By ten o'clock the morning after any concrete is laid the burlap, that has been kept wet in the meantime by sprinkling, is removed and calcium chloride spread on the surface at the rate of about 2½ lb. per sq. ft.

The Mix.—In order that the new pavement may be opened to traffic with the least delay, the usual 6-bag batch of 1:2:3½ concrete has been departed from, and rapid hardening has been secured by the addition of a variable amount of extra cement to the batch. The mix is varied so as to make possible the opening of an entire unit of the road on the earliest possible date, and for this reason some runs will be made using 10 bags to the batch, while others require but 8 bags, and still others require but 6 bags. The water is gauged to give a slump of 1¼ in. for the 6-bag batch, while the 10-bag concrete is given enough water to give a slump as much as 1¾ in. These proportions give a mix that finishes well and that just barely clears the bucket in a reasonable time. The richer mix gives enough strength that the road may be opened to traffic in 4 days, while the 6-bag batch concrete is strong enough for traffic in a week. Beam tests show a satisfactory uniform strength of about 600 lb. per square inch at 4 days with the rich mix. With these mixes and the organization and equipment described, the contractor has been laying 400 batches per 8½ hour day, with a total crew of about 50 men on all operations.

Progress.—The work has been progressing at such a rate that only for about 60 days was traffic shut off from using all parts of the highway on the part being repaved, while about half of the job was closed for only about

a month. As soon as one 20 ft. strip had been completed it was opened to traffic in order to serve local traffic in order to serve local traffic while work was proceeding on the other 20 ft. strip. This gave quick service to local traffic even though through traffic was for the most part diverted for the time being. In order to protect the men on the job two policemen were stationed along the work to keep the cehicles moving at a slow speed, and old ties were laid on the center line or job edge of the new pavement to act as a barrier. Culverts were built a half at a time so that work could proceed at a good rate. Thus work could be proceeding on a culvert even though the half on the completed side of the road had been done long before. The efficient handling of the job by the contractor, who personally supervised the work, resulted in opening each section in advance of the date required.

Those Responsible.—The removal of the old pavement and the paving of the new highway were done by G. H. Summerville, Oak Glen, Ill., contractor, for the State of Illinois and Cook County in that state. The state was represented by G. N. Lamb, district engineer; R. E. Bagby, resident engineer; and R. M. Dillon, project engineer. The county was represented by Maj. George A. Quinlan, superintendent of highways; B. D. Barker, assistant supt. of highways; W. E. Bates, construction engineer; Paul Robinson, assistant construction engineer; G. A. Davis, assistant engineer; and J. J. Hein, junior engineer.

Trackson Announces New Equipment

The Trackson Company, Milwaukee, Wis., announces the addition of a line of Trackson loaders and shovels to its present line of Trackson Full-Crawlers.

These machines are a Trackson High-lift Loader and Low-Lift Shovel, said to be as thoroughly fool-proof as such devices can possibly be made.

The use of high quality materials and workmanship guarantees strength and durability. The shovel, with a 3½-ft. lift, has a wide field of activity, replacing from 4 to 10 men and as many as four teams on excavating jobs, building grades, sub-grading, filling ditches and bridge approaches, digging trenches, etc. However, the Trackson Shovel is not designed only for digging and excavating, but also is said to be an efficient backfiller or bulldozer. It may be used for leveling or pushing materials over embankments, and will handle from 80 to 160 yds. per day, replacing hand labor entirely.

The High Lift Loader with a 7-ft. lift will load a truck or wagon in a few minutes' time, say the manufacturers. It should be a handy equipment for contractors, quarries, coal yards, industrial plants, water works and garbage departments, etc. Both machines are said to be built to stand long hours and days of constant service, and the rugged construction and simplicity of operation and repair claimed by the makers indicate reliability and consistency.

The mechanical operating principle of the Trackson Loader and Shovel has been proven sound design, says the manufacturers, who state that almost all big shovels, loaders, cranes, etc., are constructed on the same principle. Cable tighteners insure even hoisting of the bucket. The clutch is the multiple disc type with hardened and ground saw steel discs, and anti-friction bearings and an extra long pinion shaft bushing of highest grade bronze increase the machine's efficiency and strength.

The Trackson buckets are adapted to mounting on either wheel or crawler-equipped Fordsons, but for work in difficult ground conditions such as soft, loose soil, mud or swamp, sand, gravel, snow, clay, etc., Trackson Full-Crawlers will greatly increase the efficiency of either the loader or the shovel. The crawlers give the tractor a sure footing where wheels would slip or mire, enable the outfit to turn in its own length, make much larger loads possible, and guarantee the delivery of all possible power at the drawbar.

The Trackson Low Lift Shovel Mounted on the Trackson-Fordson, for Excavating, Backfilling, Leveling and Carrying Materials

Highway Research Proceedings Now Ready

The proceedings of the 7th annual meeting of the Highway Research Board are now ready for publication, and will be offered to those interested in highway research at the nominal price of $2 per copy.

The proceedings will include in addition to the committee reports, papers by Frank B. Jewett on "Industrial Research," and by Maurice Holland on "The Demonstration and Dramatization of Research," and the report of Director Charles M. Upham. The committee reports present valuable summaries of the existing scientific knowledge coming within the scope of the various committees. The topics covered are as follows:

Causes and Prevention of Highway Accidents: "Highway Accident Statistics," "Present Status of Headlight Regulation," "Color and Form of Traffic Signals and Signs," "A Survey of Accidents Involving Trucks at Hartford, Connecticut," "A Method of Measuring Relative Efficiency of Traffic Flow Through Street Intersections," and "The Railroad Grade Crossing Hazard on Rural Highways."

Structural Design of Roads: "Motor Truck Impact Studies," "Subgrade Studies," "Low Type Roads," "Sand-Clay and Top Soil Roads," "Bituminous Pavements," "Portland Cement Concrete Pavements," "Curing Studies," "Fatigue of Concrete," "Stress Measurements," "Reinforcement," and "Studies of Brick Pavements."

Materials: The factors involved in control of Concrete, "Portland Cement," "Fine Aggregate," "Coarse Aggregate," "Design of Mixtures," "Curing," and "Tests on Finished Concrete."

Highway Traffic Analysis: Analysis of various problems, "Capacity of Traffic Lanes," "Time Losses Due to Crossings, Villages, By-pass Routes, Curves, Hills, etc.," "Future of Common Carrier Transport on Highways," "Estimating of Traffic," "Study of Traffic by Aerial Photography," and "Traffic Flow Recorder."

Maintenance: "Gravel and Stone Roads," "Bridges," "Snow Removal Euipment," "Causes and Cure of Frost Boils."

Culvert Investigation: Method for estimating probable life and economic value of corrugated metal culverts.

Roy W. Crum, B and 21st streets, Washington, D. C., is director Highway Research Board.

Fuller & Johnson Announce Improved Engines

Interesting improvements have been recently made in three of the engines manufactured by the Fuller & Johnson Mfg. Co., Madison, Wisconsin. These three improved industrial engines are known as Model "NC," in 1½, 2 and 2½ h.p. One of the recent improvements to be found on this model is the solid disc flywheels and the gib key shroub, making for better appearance and greater safety and which make for smoother running. These models are designed to be mounted on steel channel

This Shows the General Appearanec of the New Line of Industrial Motors Recently Produced by the Fuller and Johnson Mfg. Co.

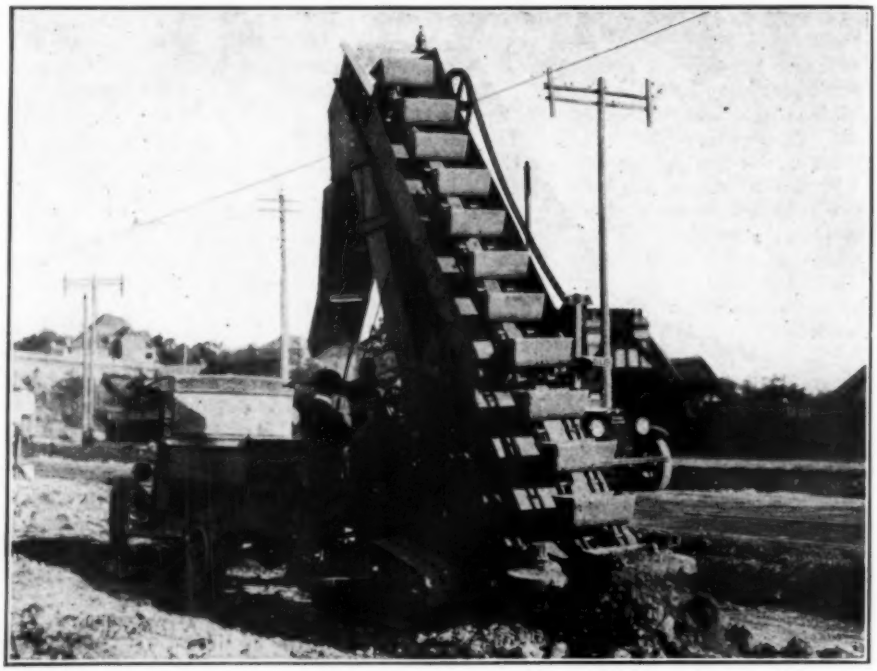
skids of 3, 4 or 5-in. channels, which may be mounted with the angles facing in or out and which are available in any length. Thus installation problems are easily met. The cylindrical fuel tank, located between the skids, is attached directly to the cylinder casting, to which it is attached by a cradle of 2-in. adjustable steel strap. The tank is strengthened with a rolled bead at the point of contact with the strap.

The gasoline filler pipe is amply large enough to permit filling without the use of a funnel, and is carried out at an agle so as to make it easy to insert a measuring rod. This pipe is fitted with a threaded cover to avoid spilling the fuel in case of a portable installation. The tank is air vented to permit rapid filling.

The throttle is easily accessible to the operator, while the water drain has been placed on the operating side of the engine. The vaporizer opening is from the bottom of the elbow, making a presentable appearance.

These engines are equipped with a simple governor that adjusts the freqnecy of power impulses in accordance with the load, thus making for efficient operation. The cooling system is comprised of good sized water hoppers and water passages entirely surrounding the cylinders to their full length.

These motors are well built for long life, low maintenance, and economical operation, according to the manufacturers.



Barber-Greene Loaders Used on Australian Roads

It is often said that of all the countries on the globe that may be compared, in mental attitude, to the United States, perhaps except for Canada, the closest approach is Australia. Given the same spirit of progress and the same type of public mentality, it is to be expected that ways of doing things will have much in common. Thus it is not surprising, since Australian engineers and contractors are careful readers of American engineering journals, to find American methods and equipment used on the construction work of that country. The photograph shown above bears out this assertion. Here we see one of four Barber-Greene Bucket Loaders owned and operated by the Main Roads Board of New South Wales, Australia. The machine illustrated is being used to remove the old macadam surface after being scarified, on the Lane Cove Road, near Sydney. This old macadam road is being replaced with a modern concrete pavement. The machine shown here is picking up the old material and loading it directly into motor trucks. The other three machines were used at the same time on this project for loading the batch trucks from the aggregate stock piles. A typical American method, isn't it?

In Daily Use by Road Engineers and Contractors

No apology is needed for bringing to the attention of road men a most valable service which has become the constant dependence of men engaged in road and street activities.

From one of thousands of messages of appreciation the following is taken:

"I wish to congratulate you upon your Road and Street Catalog. This is the most complete service on road work I have ever seen from the standpoint of both the engineer and contractor. The manner in which the subjects are grouped as regards cost data, specifications, and as a buyer's guide is original and is of great help to engineers and contractors in making up specifications and figuring estimates.

"I am in continual contact with road engineers and contractors and I find your catalog in daily use."

The writer of the above had greatly benefited from the service rendered by the Road and Street Catalog and Data Book, which accounts for his enthusiastic words. It soon becomes an indispensable campanion when its stores of valuable reference material are once discovered.

Concrete Paving Records in Wisconsin

In his fourth quarterly report for 1927, Mr. H. J. Kuelling, state highway engineer of Wisconsin, cites the following record made during the 1927 construction season in laying concrete surfacing: The E. W. Hallett Co. of Crosby, Minn., laid 1,666 lin. ft. of 20-ft. concrete pavement in 13 hours and 50 minutes, with a 32-E, 9-bag batch concrete mixer, and also established a record with 6,602 lin. ft. for the weekly high run. The 1926 record for concrete surfacing had previously been broken during the season with runs of 1,355 and 1,526 lin. ft. of pavement in 14 hours and 17 hours, respectively, by the Kramp Construction Co., Berlin, Wis., and a run of 1,363 lin. ft. in 15 hours by the Schuster Construction Co., Denmark, Wis.

Road Construction in Sweden.—Construction of roads in Sweden by the unemployment commission, according to a recent report of the U. S. consul at Stockholm, has been and still is the principal part of the work performed by that commission through relief works. This road building has entailed an expense of $20,000,000, and the concrete results are 1,900 miles of new roads, including all types from first class to ordinary gravel.

Camp and Plant Site for Pavement Job

Some Interesting Points for the Contractor Given in Public Construction News

By A. H. HUNTER
Engineer, Illinois Association of Highway and Municipal Contractors

IN the award of a contract for highway work the right of way for the road is provided by parties other than the contractor. This place to work, however, does not provide space for buildings, storage yards, cement sheds, repair shops or any of the other acts necessary to the performance of the work. All property outside the city limits of the right of way is privately owned and it is a rare instance indeed when an individual or corporation will permit the use of their property for the benefit of a contractor. In fact, the general tendency is for the public to assume that contracting operations are very profitable and one has to be a good trader to secure this space for camp or plant site at a nominal figure.

When It Does Not Pay to Put Up a "Front."—This attitude of the public has, in many instances, been unconsciously developed by contractors in general. At heart you are takers of chance and, like gamblers, boast of your winnings until these sums become exaggerated in public opinion. The common use of expensive cars, lavish entertainment or outward display of wealth creates business handicaps. When you go to arrange for rental of property the use of an expensive car prejudices the owner who may possess only a Ford or a Chevrolet. You may not all be guilty of the criticism but in many instances contractors suffer from the thoughtless acts or boastings of a few members.

There is much changing in the ideas of a contractor from job to job, and there is still more variation from individual to individual as to minimum requirements for property on which to conduct the work. Recently we heard of a contractor whose investment for plant facilities exceeded $5,000; we know of another contractor who purchased an entire farm. Possibly it was cheaper to purchase the farm than to pay rent for sufficient acreage.

Cost of Property Rental.—In our experience an estimate of $200 for rentals on property required for a plant set-up. This amount is only nominal and we are sure that it will be very rare instances when one may find it for less.

Some previous work on estimates developed the idea that such arrangement included commissary and boarding quarters. Such is not our intention. In case of boarding all expenses for such should be chargeable to the camp and balanced against the receipts for meals and lodging. As is usual, final cost records will have a separate charge for camp expense, as all such undertakings are unprofitable. At best contractors only hope to break even. Present supplies of common labor are adequate and under such conditions not many will be tempted to undertake the work of running a commissary.

The everyday handling of 60 to 80 men suggests an army of workers, some of whom are at times trespassing on private property. Accidents are unforeseen, contingencies arise when expediency demands the taking of unauthorized privileges. For such acts you are obliged to pay fairly to avoid loss of good will and public sentiment. These claims for damages may be divided two ways, actual and imaginary.

Of course, one should not feel badly in being obliged to pay one's just debts, but it is not infrequent to find some one who presents all matters of claims and contentions. He would impress you that he had been unduly abused. Probably this type of men with whom you have to deal are few in number, but you will recall their impositions long after the job has been completed.

Provision for Switch or Railroad Sidings.—Adequate provisions necessarily should be made for switch or railroad siding. Present specifications demand concrete materials of the highest order and proper railroad facilities must be provided if construction is to advance.

The public realizes the benefits of paved surfaced roads, but they cannot be expected to appreciate the energy and thought required to make them possible. The development of mechanical equipment necessary for present day work is a product of mechanical engineering and machine builders who have been engaged in the equipment industry for years. A detailed design and location of our highways represents a development of highway organization, some of which have been functioning for 20 years or longer. The ability to construct the present stretch of highways must come from constractors who have adequate finances and who have had years of experience in welding together men and equipment in an efficient organization. The highways that we see today are the result of many minds and did not come by chance. Neither did switch or track facilities come by chance. They represent an investment that was instituted for that particular purpose. The possibility of their use on your construction work suggesting that you be required to pay adequate rental should you choose to employ them for unloading purposes. It is only in rare instances that adequate sidings are available. Do not be tempted to utilize one that does not fully meet your needs. The resulting loss from inconvenience and reduced production will be more expensive than if you had provided proper trackage at your own expense.

In a general way the length of track required must be slightly more than twice the length of cars required to supply the material for a maximum day's run. In some instances you may have the advantage of frequent switching which will assist you in handling cars, but even so, the length of the siding cannot be materially reduced.

Of course it is expected that you will select such a point for your material yard as will minimize the haul to the road. The expense of grading and arranging for the track is governed by the nature of the ground, so that you will be limited in choice of location for your plant situation.

Rental Charge for Sidings.—In our experience of former years we found that the investment for siding required from the railroad company would be in the vicinity of $2,500 to $3,000. With allowance for material rented from railways, which if properly returned, would result in some saving, so that the net cost averages about $1,500. It is usual to have the railroad demand a check covering the entire cost of this work. Upon its return credit will be allowed and rebate made. Experience with rebates from railroad companies are not so satisfactory. Even though you get a fair allowance in the final adjustment you will always have more or less difficulty before a final settlement is made. A personal experience might be of value. A check for $3,200 was placed in the hands of the railroad company to guarantee payment of expenses of construction. The pavement work was finished, the siding was removed and an adjustment of about $1,500 was pending for more than six months. Letters passed through the mail to no particular satisfaction. One day the general freight agent was advised of a large shipment of construction material, which he hoped could be routed so the railroad could have advantage of such a nice long haul. He was informed that his railroad might secure the haul but it would only take place when the outstanding claims against his railroad would be adjusted to our satisfaction. Although he could not advise definitely, the matter was taken up by the auditing department, and he hoped to have something more definite in a few days. Three days later a draft was secured which constituted a very satisfactory settlement. Probably many of you have had this same experience. Other opportunities for advantageous adjustment of siding expenses may be had if a choice of railroads for delivery purposes is possible. This ideal is seldom found.

Delivery of Equipment to Unloading Point.—The delivery of equipment and supplies to the unloading point requires an investment in labor. So far as can be learned very few contractors keep any separate account of this item, possibly combining this expense with overhead or some other item. Taking the equipment to a given point, unloading it, getting it in a position for work

and returning it is an expense rather hard to estimate. It is our judgment that the handling of equipment and construction of necessary conveniences for this operation and the removal of same after the work is finished should be estimated at about $1,600.

Need for further information on this subject is being expressed through requests to trade associations. Recent contact with the General Manager of the Construction Division of the A. G. C. indicates that contractors are seeking information. It seems to us that cost records should include an item for this expense distribution.

Austin-Western Develops New Graders

The Austin-Western Road Machinery Co. has recently brought out three new road graders. Each model is regularly equipped with an 8-ft. blade and two are light enough in weight to fall within the patrol grader class. The third is heavy enough to operate behind all but the most powerful tractors.

A distinct innovation is seen in the new Western No. 22 Leaning Wheel Grader, one of these new machines. This is said to be the first patrol grader to be built with leaning wheels and telescopic rear axle. Its design and construction make it suitable for light grading and ditching as well as for patrol maintenance.

Leaning wheels are useful in grading and ditching as well as in some of the heavier forms of road maintenance; while the telescopic axle in combination with leaning wheels provides all around efficiency unequalled in machines which do not have both features, according to the manufacturer.

The wheels are regularly fitted with plain bearings, but the manufacturers strongly recommend Timken tapered roller bearings, which they are prepared to furnish when ordered. Three-in. grooved flat steel tires are furnished and rubber tires may be ordered, as they are of especial advantage when the grader is for use on hard surfaced roads. The rear axle is of the well known telescopic type used on other sizes of Austin-Western Graders for many years.

Each rear wheel can be extended 11 in. from the closed position, and as the two wheels have separate controls, it is possible to work with both of them pulled in, with both fully extended, or with one pulled in and the other extended—the latter being a very useful adjustment when making second cuts.

The blade assembly and lifting mechanism are of the most advanced design known to modern engineering, it is claimed. The blade raising gears and worms are cut steel, while the raised rods have ball and socket connections at both ends.

Six horses can handle this grader very well, though it is sturdy enough to work behind a light tractor. Either the horse tongue or the steerable engine hitch shown can be furnished. The Western No. 22 Leaning Wheel Grader weighs 2,200 lbs. with the horse hitch and 2,500 lbs. with the engine hitch.

Those who are familiar with the Western Patrol Grader No. 1 will be glad to learn that the No. 12, the lightest of this group of newly developed graders, has all of the features that made the heavier model so popular. The No. 12 can be handled by two horses on all kinds of work.

Every feature that has contributed to the success of the No. 1 will be found on the No. 12, although, of course, in some cases on a smaller scale.

Like all Western graders, the No. 12 is hot riveted throughout, except in the very few places where bolts must be used, making a good tight construction.

The draft beams through which power is transmitted to the blade, are 4 in. deep, the circle is the heaviest 5-in. channel made, while the connection between the ends of the circle is the heaviest 8-in. channel made. The circle is 41 in. in diameter, which insures steadiness and also reduces pressure on all contact surfaces.

The balls of the ball and socket joints are drop forging with heavy bases large enough to be riveted with two ⅝-in. rivets to the parts holding them.

The spokes of the wheels are hot riveted into both the hubs and the rims, for which reason they will never work loose, or crystallize and break off, the manufacturers claim, while a renewable sleeve placed between the axle and the wheel box forms the bearing for the box and takes all the wear. This sleeve has a square opening where it fits on the axle, so that when one side of the sleeve becomes worn it can be turned and a new wearing surface exposed to the box. Thus the life of the sleeve is long, and when it finally wears out it is only necessary to replace an inexpensive sleeve instead of a much more expensive wheel box or axle, according to available information. The hub is equipped with a tight fitting dust cap to protect the bearing.

The Western No. 12 Grader weighs from 1,200 to 1,350 lbs., depending upon the blade and hitch equipment.

The No. 55 Grader, the third in the new line, is a heavy duty grader built to work behind tractors of 40 h.p. or less. Simplicity is one of its most noticeable features, yet nothing has been omitted that would add to its ease of handling.

Its arched frame is not only exceedingly strong, but provides ample blade clearance, while placing the operator's platform but 21 in. from the ground.

The frame can be side shifted on the rear axle a distance of 30 in., while the axle can be pivoted as much as 20 deg. to resist the side pressure of the dirt on the blade, and hold the rear end of the machine to a straight course at all times.

Both front and rear wheels have 6-in concave tires. The front wheels are 34 in. in diameter and the rear wheels 44 in. Spokes are riveted to the hubs and tires will never work loose or crystallize and break off.

The No. 55 is regularly fitted with Timken tapered roller bearings in all four wheels—a feature that is bound to appeal to experienced grader men.

The blade raising worms and worm gears are cut steel, and run in baths of grease in dust proof housings.

A powerful adjustable blade raising spring enables the operator to raise the unusually heavy blade assembly with practically no effort.

There are many kinds of work that can be handled by a strong, heavy duty, 8-ft. grader better than any other sizes. The Western No. 55 was designed to meet such demands.

The Western No. 55 Grader weighs 5,500 lbs.

New Road Building and Maintenance Equipment to Save $340,000,000

There will be an economic saving of $340,000,000 in the road program in 1929, it was estimated by the American Road Builders' Association at its recent annual meeting. This may be accomplished by the utilization of the recently developed road-building and maintenance equipment and the latest improved construction and maintenance methods.

An increase of 10,000 miles of hard surface roads or approximately 31,000 miles of low cost improved roads can be obtained if this saving is applied to the construction of additional miles of roads to the highway system in the United States.

The newly invented and developed road equipment for the construction and maintenance of all types of highways will be on exhibition and the latest approved road building and maintenance methods will be described at the next exposition and convention of the American Road Builders' Association, which will be held in Cleveland, O., Jan. 14-18, 1829.

There will be 450 carloads of road building and maintenance machinery on exhibition, including every type of equipment used in the construction and maintenance of all types of streets and highways. Over 30,000 road builders will be in attendance from all the states, counties and cities throughout the country, as well as large delegations from all Pan-American countries.

The Convention and Road Show of the American Road Builders' Association is the largest convention of its kind in the entire world, equally important to the road constructor and to the road user.

Highway Trees and Shrubbery

A Phase of Roadside Development Discused in Paper at 14th Annual Highway Engineering Conferences at University of Michigan

By PHELPS VOGELSANG
Forester, Michigan State Highway Department, Lansing, Mich.

THE topic of roadside development is a general subject that may be looked at from several standpoints. It may be a discussion of shoulder maintenance, drainage problems, back slope specifications, guard rail building and maintenance, the building of fences along the property line or the growing of trees and shrubbery along the highway. As a forester, I believe I will confine my talk to that 20 or 30 ft. between the ditch line and the fence. This small portion is the center of activity for what we call roadside beauty.

What Is a Beautiful Road?—Beauty is a relative word and its meaning depends upon the individual. Some appreciate one kind of beauty, while others appreciate another. Your praise may be confined to the smoothness of the concrete or the gravel; another's to the nicely painted straight guard rail or the well made shoulder, ditch and backslope. You may see only the nice row of trees and the shrubbery. This leads to one conclusion; everything must be just right in order to get the best effect. Your trees may be beautiful, your location exact, your surface smooth as glass; but that rickety old guard rail spoils everything. The whole right-of-way makes up the picture and one ugly thing may spoil it. Roadside beautification cannot confine itself to the row of trees along the road. Every field, lake, marsh, tree and shrub contributes to our picture and upon their treatment depends a beautiful or ugly effect.

Did you ever ride along a nice smooth piece of road; you weren't tired, but you just couldn't keep awake? Why was that? It deals with what you might call monotony or sameness. We have all had our experience with the monotonous drive, the straight prairie road, the 50-mile swamp road or the long stretch through the timber. Do we want a beautiful row of maples on every mile of the road in our state? I hope not. It is the change of scenery that makes up the beautiful drive. If it were not for the bare stretch we would not appreciate the wooded section. Roads must be interesting, especially in a state like Michigan where tourist travel is a popular thing.

It seems our problem, however, is not one of cutting down trees to make a change of scenery, but instead the care of those few trees we have, and the planting up of the barren places. The monotony that bothers us is of the bare type. Here a nice large elm, here a mass of dense shrubbery, here a lake, here a wooded stretch, here an open spot, and so on; that's what makes an interesting and beautiful roadside.

Treatment of Roadside Trees.—How should we treat the roadside trees and shrubbery? We want a neat, clean looking road and still keep it looking as natural as possible. We want plenty of trees and still we do not want to be fenced in by them. A solid mass of trees and shrubbery for any great distance is very monotonous and undesirable. We want a glimpse of the country as we pass through and the scene is best brought out when framed with trees and shrubbery. The mixture of trees and shrubbery in a naturalistic design seems to be the ideal. In my estimation the roadside is no place for formal landscape designs, unless it be through highly developed town or village property. Transit set rows of uniform trees seem to be in favor with the ordinary roadside planter, no matter the naturalistic surrounding. In such a planting one tries to insert naturalistic species into a more or less formal and rigid design, and as a result does not really attain the best effects of either. A slight irregularity with the use of informal trees and shrubs seems correct for our average type of highway. In Nature trees are most beautiful, so why not keep them at the best along the roadside?

It is true that too much irregularity of the planting will be a detriment to traffic and telephone lines and does not give that well groomed appearance to the road. We desire neatness of appearance in combination with natural effects. Trees evenly spaced and in straight rows through property of a formal design are of course in harmony. Such conditions are usually found in and about cities and towns.

Selection of Trees and Shrubbery.—What trees or shrubbery are best suited for our roadsides? All of our natural trees have a place in roadside work, although there is more economy in selecting those of desired qualities and length of life. One would not ordinarily plant a poplar tree where a ample, oak, or elm would grow. The popular lends it beauty for perhaps 40 years, while the maple may stand 100 years or more. The cost of planting is very nearly the same, so the maple would outweigh the poplar from that standpoint. This is important in the cleaning up of roadsides. When brushing a roadside the swamper must have in mind the species that should be saved. The type of soil also governs the specie; so we are forced to plant only those trees that are adapted to that soil. Climate and moisture also play their important part. Plant the species that grow naturally in the vicinity and most of the difficulty is overcome. No two highways are exactly alike, or no two trees of the same proportions, so that judgment in their treatment is the most important thing to be considered. There are a few rigid rules laid down by mother nature and the rest depends on your judgment and eye for beauty. In road building and maintenance it is a general practice to leave the beauty of the roadside to the discretion of the laborer who is given an axe and told to clean up the road. He cuts everything on the right of way, or he cuts the desirable shrubs and leaves the undesirable ones. Rarely, if ever, does he cut what he should and leave what he should. Roadside brushing and trimming is a job for experienced hands and should be governed by the most rigid rules and the strictest of supervision. Men must be trained to work according to a definite landscape plan which will be used throughout the state before uniformity can be attained. We find that construction crews will cut everything that is green on the right of way before they start building the road, having no regard for the final picture when their work is finished. Why shouldn't roadside development start when road building starts?

Trees Within Construction Limits.—A scientific plan for treatment of trees to be left within construction limits is desirable. As a rule, trees will die if a fill is made around them, or if the roots are cut off on one side due to a cut section. The welling out of the dirt around such trees and severe pruning to keep them alive should be done as soon as possible. In traveling about the state I have noticed, not a few, but hundreds of trees that have been killed by excavation during construction. Such trees seem very prominent along the road and give a poor impression to the public. With very little effort most of these trees can be saved and in my judgment it is well worth while.

There are other rules to follow such as traffic safety and future changes in the highway. I do not figure that a tree is worth a man's life, and any one tree dangerously close to the gravel or pavement may spell death for the motorist. All plantings should be well back on the right of way. This can be made definite by saying that trees and shrubbery should be kept back of the ditch line. It is absoltuely essential that dangerous corners be taken care of where trees are involved. Two approaching motorists must be able to see each other in time to avoid a collision. This does not mean, however, that all our corners must be barren spots; a complete ground cover of low growing shrubbery beneath the line of sight and the trees undertrimmed above the line of sight is sufficient.

Positions for Trees and Pole Lines.—It is folly to plant trees 20 ft. from the center line on a highway that in ten years or so will be widened to a 40-ft. roadway. Tree planting is a long-time investment and the future of the highway on which you are planting

must be considered. We conclude then that right of way is very essential in the planning of roadside development work. It is impossible to maintain a telephone line, a power line, and trees, on a right of way where there is only room for a telephone line. Insufficient right of way is the one largest drawback to roadside development. Right of way first, and all other development can easily follow. When sufficient right of way is obtained, definite positions for telephone lines and tree growth can be determined and enforced. Pole lines can be set behind the trees and shrubbery where they will not show and will not interfere with the trees. Tree trimming for pole lines has always been a bugbear to highway officials and relief can be had only when there is enough room on the road for both pole lines and trees. We have several important highways in Michigan that are littered with pole lines and very little if any tree growth. Such roads present a depressing, dead effect instead of one of life and beauty. These roads are avoided by the pleasure driver.

Economic Value of Trees and Shrubbery.—Some may not see the economy of beauty on the highways. Let us consider another value of trees. Trees and shrubbery properly placed along a road will act as a perfect and permanent snow fence. A wooded section will never drift with snow. Wind action through brush has the same effect as it does when passing through a snow fence. A compact planting of massed shrubs at the edge of the right of way is the cheapest snow fence obtainable. The original cost of planting is higher than the cost of snow fence, but the upkeep is negligible in comparison as only occasional trimming and the removal of dead wood is required for maintenance. It is undesirable to plant evergreens or deciduous trees and shrubs in hedge form, due to the monotonous effect produced, but natural appearing masses of mixed species give the desired beauty and protection. Such a snow barrier must be placed at sufficient distance from the road so as not to place the drift in the road.

I might also outline the effect on humidity caused by trees and what this means to the maintenance supervisor. Trees, in fact all plant growth, help to prevent erosion by cutting down wind and rain velocity and also give off moisture by evaporaton through the leaves. This tends to keep the soil in a moist condition which bears directly on dust lay. Have you ever noticed the difference in effectiveness of calcium chloride when used on gravel roads through wooded sections as compared with that used on roads through barren areas? It is a fact that the higher humidity caused by moisture evaporation in tree growth keeps the road in a damp condition and thus makes the chloride more effective and preserves its lasting qualities. You also have the prevention of washing during the spring rains in wooded sections. This means that more chloride stays on the road and is utilized. You will notice that one application of chloride in wooded sections will go almost as far as two applications in barren sections, all else being equal. Is not this a commercial saving? Of course the degree of effectiveness will depend upon the amount of tree growth, but each tree will add to that degree. Trees also tend to keep a more even temperature the year around. This also aids in general road maintenance. It may aid in reducing the effect of spring breakups, in that frost will not penetrate the road surface as deeply through wooded sections as in barren sections.

The State Highway Department has within the last year proposed a budget, which is being spent to obtain wide right of ways through virgin timbered areas in Michigan. Our state as well as all other states, is being deforested very rapidly, which leaves only burnt-over stump land to greet the eyes of the tourist. Timber not only keeps the roads beautiful, but is an economical saving in snow removal cost, and will pay for itself over and over again in future years. Timber also has a direct bearing on tourist travel, and if Michigan wishes to retain her place as a summer playground, every possible step must be taken toward conservation. Every county in the state should consider this more, before it is too late.

In the present day, the problem confines itself to one of conservation of roadside growth, more so than the planting of trees, and every county can well afford to seriously consider roadside development and take steps to conserve all possible tree and shrubbery growth on the highways.

Lakewood Announce Batch Box and Car

The Lakewood Engineering Co., Cleveland, Ohio, announce a new Batch Box Car and Batch Box for road work. The car, No. 255-B, is designed with a carrying capacity amply large enough to handle two 48-cubic foot batch boxes.

The frame is of 6-inch ship channel, strongly braced and reinforced. Axles are alloy steel, heat treated, having a journal 2½ inches by 6 inches. Either the Lakewood Cage Roller Bearing, or Hyatt Bearings, can be furnished. Complete spring draft rigging is standard equipment. Wheels are of cast steel, 14-inches in diameter.

The New Lakewood Batch Box and Batch Box Car for 27-E Paver

The new type of Lakewood batch box incorporates the feature of adjustable trunnions, making it possible to alter the tipping axis of the box to allow for variations in sizes of batches that may be encountered on different jobs. The growing practice of weighing materials has made this feature of greater importance than ever before. Another feature is the use of a chain in the buttom of the cement compartment which helps clean the cement from the compartment when the box is dumped.

The 48-cubic foot size of box seems to be preferred by most contractors, as this has ample capacity to handle practically any batch now being used in the 27-E Pavers. However, these boxes are made in 41 and 45 cubic foot capacities to meet any other requirements of mixing or paver capacity.

R. W. Crum Appointed Director of Highway Research Board

Announcement is made by Professor F. H. Eno, chairman of the executive committee of the Highway Research Board of the National Research Council, of the appointment of Mr. Roy W. Crum of Ames, Iowa, as director of the board, effective April 1, 1928.

Mr. Crum's experience in research work well qualifies him for this position. After graduation from the Iowa State College in 1907, he was engaged on the engineer corps of the Pennsylvania Lines, following which he returned to Iowa State College as associate professor of civil engineering. He remained in this position for twelve years, during which time he was engaged on research work for the Iowa Experiment Station. Since 1919 he has been engineer of materials and tests with the Iowa State Highway Commission, where he has conducted many highway research studies. Mr. Crum has been a member of the committee on character and use of road materials since the organization of the board, and in 1925 he was appointed chairman of the culvert investigation conducted by the Highway Research Board.

Mr. Crum is the author of a number of important research papers. He is a member of the American Society of Civil Engineers, the American Society for Testing Materials and the American Concrete Institute and is active on several research committees of those organizations.

Mechanical Spreading, Raking, Finishing on Asphaltic Concrete Pavement

Machine Used in Kern County Described in California Highways

By C. S. POPE
Construction Engineer, California Division of Highways

THE desirability of securing a machine which would mechanically spread, rake and finish asphaltic concrete has been evident for many years.

Objection has been made in the past that any machine used for spreading and finishing portland cement concrete would not be suitable for asphaltic concrete, because the asphaltic concrete would stick to the spreading and leveling devices if they were not heated or oiled, and further, that such machines were not provided with suitable rakes, which are essential in asphaltic concrete construction.

It was the belief of the writer that the use of an ordinary spreading machine such as is used for spreading and kneading or tamping Portland cement concrete pavement would not give the results which were desired and, therefore, it was decided to remodel an Ord finishing machine by placing a rake in the machine in such a position that it would satisfactorily rake the material into longitudinal furrows. It was thought extremely important that the furrows should be longitudinal, since the material would then be raked in such a manner that if there was any incipient deformation, it will be through the formation of longitudinal ruts of slight elevation rather than through the formation of transverse waves which are the curse of pavements of this type.

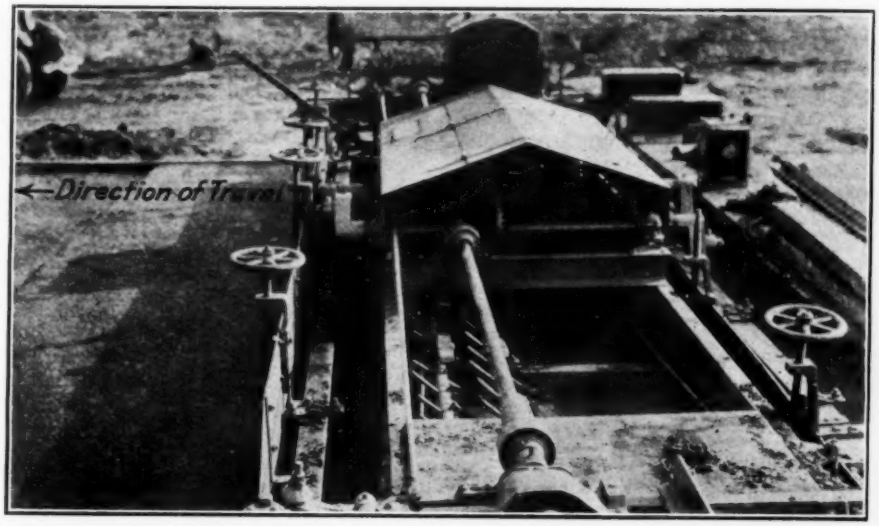
The machine described herein was placed on a contract for asphaltic concrete surfacing, some eight miles in length in Kern County, Cal., near the town of Delano. Its success was almost immediately evident and led, not only to the purchase of the machine by the contractor, but also to the purchase of a similar machine for an adjoining contract of similar length.

Description of Machine.—The machine consists essentially of a motor-driven steel framework running on flanged wheels resting on the side forms.

A spreading blade which is adjustable for height spans the width of the pavement at the front end of the machine.

Back of this blade, the raking teeth, which are inclined to lift the mixture, are arranged in rows attached to shafts or channels in such a manner that they may be lifted or given any desired inclination.

So far, the work indicates that two rows of teeth spaced 6-in. centers are sufficient.



View of Machine with Teeth Reversed to Clear Mixture

The Machine in Operation; Note Crew Required to Spread 8 400 Tons Per Day, 20 Ft .Wide

Such an arrangement forms the furrows 3 in. on centers and gives a sufficient loosening and distributing action.

Back of the raking teeth is a second strike-off and finishing plate also spanning the full width of the pavement.

Both strike-off plates are set vertical and have a side-wise motion which shears the material and permits the machine to advance with the use of a minimum of power. While the present rakes do not vibrate, it is planned that they shall be arranged to do so in subsequent machines.

The strike-off blades are adjusted to the proper elevation by means of hand wheels.

The raking apparatus was, therefore, so arranged that the furrows should be made longitudinally and practically straight. Should a slight waviness of the furrows occur, due to the necessity of vibrating the teeth, it will probably not be found detrimental. The use of teeth is believed essential to secure uniform texture in the mixture upon the road.

In the practice it was found that in

cases where the mixture was piled up in front of the screeds or strike-off blades to a greater extent near one end than at the other, without the use of the rakes, certain areas showed that an increased weight of material had been accumulated by being packed down under the weight of the first screed and the second screed by merely continuing the process gave a pavement, while it had a smooth surface, was really of non-uniform density in different parts of the cross-section. The use of the rake broke up this condition and allowed the second screed to spread the material more uniformly than if the rakes were not used.

The use of the raking and finishing machine will, it is believed, accomplish several objects. One of these is that it removes the uneveness of surface which causes of shock and therefore deformation of the pavement, and the other is that it gives a proper distribution of material over the whole surface so that there is no possibility of any accumulation of material in any one area which would have a density different from that of the rest of the pavement, which would lead to an uneven cross-section or a high place in the surface.

Paving Operation.—The most efficient method of operation in the widening and surfacing of an old pavement is as follows:

The shoulder widening is first spread to the level of the old paving and rolled. The old concrete base is painted with a coat of emulsified asphalt which provides a tack coat for the leveling course.

The header boards or side forms which are of wood 3 in. in width are set to the grade of the leveling course or base.

The asphaltic concrete mixture is hauled to the work in 3½-ton, pneumatic-tired trucks and is spread by means of small spreader boxes for the shoulder widening and by large boxes about 9 ft. in width for the leveling course or base.

The spreader boxes distributes the hot mix in excellent position for subsequent work.

The mechanical finisher is then set to work spreading, raking and finishing the leveling course and is immediately followed by the rollers necessary to compress the asphaltic concrete.

After the leveling course has progressed a sufficient distance, the mechanical finisher is returned to the location of the surface already spread and the spreading of the surface is begun.

In order to secure the thickness required for the surface course a wood strip 1½ or 2 in. in thickness is nailed on the base of leveling course side form and to secure the necessary extra height of surface required to compensate for the compression of the asphaltic concrete surface given by the rollers, steel plate ⅜-in. in thickness by 3 in. in width are temporarily nailed to the top of the header strips. These places are removed just in front of the rolling.

After the first passage of the rollers over the surface, the finish coat or void filling coat consisting of fine broken stone or gravel coated with asphaltic cement is drifted onto the surface and immediately rolled into the pavement. The result is a smooth, uniform, non-skid surface.

The spreading, raking and finishing machine operates at a speed of about 250 ft. per hour and will easily spread 400 tons of hot mixture per day, on a 20-ft. width of roadway.

Advantages Claimed.—The advantages obtained by the use of this machine consists of

(a) Economy of material;
(b) Decrease in hand labor;
(c) Increase in smoothness of paving.

In ordinary hand-raked work even with careful supervision, there is a loss or excess of material used, due to uneven spreading of base or surface. The cross-section of the finished pavement may vary considerably from the established cross-section and yet not be apparent to the eye. Also, there may be a uniform thickening of surface which is not observable even though the cross-section be correct. With the use of these machines, this extra material is very largely saved and its amount is estimated by engineers in the field at from 3 to 10 per cent of the material used for surfacing.

Ordinarily, the spreading of surface course 1½ in. in thickness is a difficult matter but with this machine, it presents no difficulty whatever.

With asphalt concrete running from 1,200 to 1,800 tons per mile on 20-ft. resurface at about $5.50 per ton, the possible economy is readily apparent.

The immediate decrease in hand labor is not at once apparent though on one contract the labor crew is reduced to nine men including the foreman and machine operator for the spreading of 400 tons of mixture per 8-hour day. It is probable that future work will show a further reduction in labor so that the ultimate saving in men will be sufficient to influence a reduction in the prices bid for paving.

On asphaltic concrete spread by hand methods, tests made under the direction of the author indicate that an average smoothness of 18 units of roughness per mile, as shown by a roughometer, such as is used by the Bureau of Public Roads, was about the low limit that could be expected. This was about three times the roughness obtained on the best Portland cement concrete pavement on its completion.

The first few days' use of the asphalt concrete finish machine indicated that a roughness of not more than 10 units per mile could readily be obtained and that side sway of motor cars due to uneven cross-section was greatly reduced.

Since it is necessary to move the machine back on the job for the construction of surface after having laid base, means must be provided for its rapid transportation.

It is the opinion of the writer that the development of this machine presents a distinct advance in the art of paving as applied to asphaltic concrete and one that will have a far-reaching effect on the use of this material.

While the original idea of a mechanical finisher and its general details originated with and was pushed to a conclusion by the author, credit is due to many others for thoughts and ideas contributed during the construction and operation of the trial machine.

During May, 1927, W. F. Herin, Assistant Resident Engineer, and H. B. LaForge, Resident Engineer, in discussing the matter of more efficient spreading, advanced the idea that material might be spread by the use of strike-off blades drawn by hand. The author felt that it would be necessary to include a rake for the experimental work and that eventually the whole operation should be done by machine.

The first experiments were carried out by Mr. Earl Withycombe, Assistant Construction Engineer, on work near Merced and near Larkspur. These were so successful that arrangements were made with the Edward R. Bacon Company to secure an Ord tamper which was remodeled for the more extensive experiment. This machine was put in use as stated before during the latter part of September or early in October. Many points had to be worked out in the field for which great credit is due to Mr. Withycombe and also the contractors, Force, Currigan & McLeod who assisted in putting the machine on a sound working basis. There seems little doubt that the small expense to which the state has been subjected in the development of this machine will be repaid many times over in the better and more economical pavements which can be laid with this method.

1929 Convention of A. R. B. A.—The 1929 convention and road show of the American Road Builders' Association will be held in Cleveland, O., during the week of Jan. 14th. Extensive additions to the Cleveland Public Auditorium have been completed and will afford facilities for the convention program and the road show to be held simultaneously in the Auditorium. Charles Upham, National Press Bldg., Washington, D. C., is director.

Maintenance Equipment Costs

Data for Gravel Roads in Gogebic County, Mich., Given in Paper at 14th Annual Michigan Conference on Highway Engineering

By C. F. WINKLER
Engineer-Manager, Gogebic County Road Commissioner, Bessemer, Mich.

NOT so many years ago a gravel maintenance section was about 7 miles long and was maintained by the use of a small drag or small patrol grader dawn by a team of horses. This equipment soon proved inadequate, not only because of the limited mileage, but also because of its lack of weight. The next step was the substitution of farm tractors for horses, and heavier graders to cut the road metal. These outfits, although much cheaper than team labor, when mileage and class of work was considered, soon ran up an enormous repair bill for the tractors, besides requiring two operators. Costs per running mile for this type of tractor were on the average of 80 ct. per running mile. To this cost must be added the cost of the grader and its operator. This class of machine averaged about 20 running miles per day and maintained approximately a 10 mile section.

Tractor Patrol Graders.—Then the road machinery manufacturers placed on the market the one-man, tractor operated, patrol grader on rubber tired wheels. This machine is a very economical and efficient patrol unit. One unit is capable of maintaing a section of road 20 to 25 miles in length, and of keeping that section in good repair. It is economical because of its rather low first cost, low repair cost, the large mileage and one-man operation. It is efficient due to its weight, ease of control and because it can be used for scarifying. These machines will operate for about $11.75 per nine-hour day; will travel on a year's average, about 30 miles per day at a running mile cost of less than 50 ct. per mile. Therefore, compared to the steel wheeled farm tractors drawing graders, the dragging cost has been cut 50 per cent per running mile; the mileage covered has been increased from 18 to 30 miles per average day, and the character of the work has been greatly improved.

Motor Trucks with Spring Blades.—This type of equipment proved quite efficient and economical with the army type of trucks, where the first cost was very low and the consequent daily rental or depreciation rate was a minimum. The heavier trucks, however, when purchased as new equipment, cost approximately four times the amount of the patrol graders. Granting that the repairs are less, one truck to compete in cost with a patrol grader must cover at least the same mileage as two patrol graders, or must be able to maintain a section 50 to 60 miles long. The truck will easily cover such mileage, but dragging carried on at this speed in ordinary dry weather is not efficient and will not eliminate irregularities and cut off chatter bumps. So evidently a cheaper unit must be purchased to compete with a tractor patrol grader. A truck of 2-ton capacity, costing in the neighborhood of $2,500, may answer the purpose, but because of its lightness and inability to scarify rough stretches of road, will need the assistance of a tractor operated machine at intervals. The cost of operating a $2,500 truck with a spring blade, is about $18 per day, as compared with a tractor patrol grader at $11.75 per day. It is very evident then that the truck must cover at least 50 per cent more road and must maintain a section of road from 40 to 50 miles in length. This is quite a maintenance section for one truck.

Hauling with Teams.—Another major portion of the maintenance of our gravel roads, is the transportation of material. Horse drawn vehicles in some instances are used on hauls up to 2 and 3 miles in length. This method of handling gravel or any road material for road maintenance has no defense from a standpoint of economy, except possibly where a seligh-haul can be utilized. The average ton-mile cost for team and wagon is about 60 ct. The average ton-mile cost for selighs where large loads of 3 to 4 tons can be handled, is not less than 25 ct. per ton mile. When the slowness of the work and the inability to dump loads is considered, even under most favorable conditions, the team haul is not economical.

Tractor and Trailer Hauling.—Tractors and trailers are used in some instances on the longer hauls, and this is an improvement over horse drawn vehicles. However, under ideal conditions and for hauls not exceeding 2 miles in length, a tractor hauling three 5-ton trailers cannot haul for less than 22 ct. per ton mile.

Truck Hauling.—Trucks have become almost universally used as the unit for hauling materials for road maintenance. Here again the choice of trucks, both as to first cost and capacity, is a matter of judgment. Army trucks so cheaply sold to counties after the war were almost universally used and were a decided means of introducing the truck haul in our counties, and of subplanting the team haul. These trucks were of all types and descriptions and mostly on hard tires. The depreciation charge off was small, being about $300 to $400 per year, but repair costs for some reason or other were always excessive. Experience gained in using all 5-ton trucks, the ton-mile cost over a period of years with this type of truck, was 17.1 ct. per ton-mile.

These figures were so encouraging and the use of large capacity trucks so apparently satisfactory and economical, that Gogebic County has for its new equipment, large capacity high-powered, high-speed trucks. Although these trucks are comparatively new, still the running mile cost, the ton-mile cost and the daily average mileage seem to justify, at least by comparison with the army type truck, their continued use from a standpoint of economy. The average daily mileage of the army type trucks over a period of six years, was 44.6 miles, the ton-mile cost, as stated above, was 17.1 ct., and the cost per running mile, 41.9 ct. Using the newer trucks of 5-ton capacity, on dual penumatics, costing $8,000 or more, with depreciation figured on a 5-year life, these same costs are as follows: Ton-mile cost, figured over a period of two years. 14.3 ct., daily average mileage, 60, cost per running mile, 37.4 ct. These figures are all averages, figured on a basis of working days and tons hauled and include all items of operation, insurance, depreciation and repairs, with the exception of office overhead. So that the high-speed, high cost trucks show a gain over the low cost, slower trucks, in mileage per day, of 35 per cent, a saving of ton-mile cost of 16 per cent and a saving per running mile of 10 per cent. When the extremely low depreciation charge on army trucks is considered, the use of the newer trucks is surely justified from a standpoint of economy.

The roads maintained as county roads, are today as a rule, more or less improved, and having a compacted base, carry the large loads during the construction period. A 5-ton truck on pneumatic tires, will travel with full load at a speed from 20 to 25 miles per hour, depending on the grades, carry twice the amount of a 2½ ton truck at a very slight increase in operating cost. For spring maintenance and other jobs of minor size, such as patrol section patching, a few of the smaller trucks are necessary.

Crushing and Screening Plants.—Gravel crushing and screening plants are a necessity if the roads are to be cheaply resurfaced. The application of resurfacing gravel is usually limited to 2 or 3 in. loose measure, and production of 5,000 to 6,000 cu. yd. suffices for quite a stretch of road. In order to keep within an economical haul, frequent set ups of the crushing plant are necessary, and today we have on the market portable crushing and screen plants that really are portable. Their purchase and use is economy. Such a plant can be purchased with power and drag scraper, for about $12,000 to $13,000, having a capacity of anywhere from 150 to 300 cu. yd. per day, depending on the amount of oversize in the pit. Since such a plant can be set up for about $275 and dismantled and moved for about $240, it can be moved two or three times per season, and a great saving effected in truck haul. These portable plants are usually equipped with a jaw crusher and in

gravels in which the boulders are close grained, finely crystaline igneous rocks, the replacement cost of jaws is rather high and the output of the plant limited. Where these conditions exist and where the amount of material to be crushed is about 30 per cent of the whole, a 9x36 in. jaw crusher cannot be expected to turn out more than 135 to 150 cu. yd. per day of 1-in. material. The cost of material of this kind average 53.6 ct. per cubic yard.

Wherever a large amount of crushed material is to be used and therefore a long time set up is to be made with a larger daily capacity, a non-portable or semi-portable plant with a gyratory crusher is advisable. The cost of setting up and assembling such a plant with about an 8-in. gyratory, screens, bins, and rejections returns, is about $800. However, the added overhead is soon made up by lower operating, upkeep costs and increased output. The costs of producing material from pits containing 90 to 95 per cent igneous rocks with about 30 per cent to be crushed, was 45.1 ct. The amount of oversize material is a very decided factor in the cost of crushing.

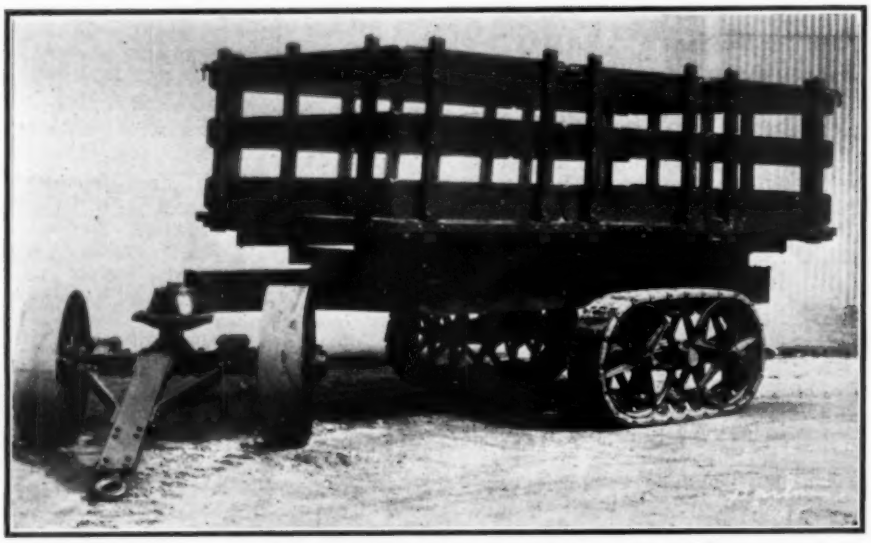
Wheel scrapers were sometimes used to handle gravel from the pit to the plant conveyor. The cost of moving material in this matter is approximately 16 ct. per cubic yard. A great saving over this old method is the drag scraper outfit, set up to drag into a hopper over the conveyor belt, and operated by one man. Even with a daily limited output of 175 cu. yd. per day, gravel can be handled a distance of 400 to 600 ft. at a cost of 8 ct. per cubic yard.

Another great improvement and a decided step towards economical production of crushed gravel, was the introduction of the shaker feder to equalize the load on the conveyor or feeder belt, and to eliminate alternate peak and light loads in the crusher. By keeping the crusher fed continuously at capacity and eliminating entirely peak loads, the output of a crushing plant can be increased nearly 25 per cent.

Statements as herein contained are given as the result of the writer's experience in Gogebic County and are the result of careful accounting and personal supervision and contact. Local conditions vary extensively throughout the state and even between adjoining counties, so that greatly varied opinions are undoubtedly held and can be justified by experience.

New Miami Platform Body Trailer

The new Miami Model CR-21 Platform Body Trailer is constructed so as to carry two-thirds of the load on the rear creeper wheels, and the other third on the front steel wheels. The construction is such that the fifth-wheel can rock on top of the axle, as the drawbar is hinged directly to the front axle. This allows the trailed to be used with any make of tractor, for any difference in height between the tractor and trailer in negotiating any uneven ground is adequately taken care of by the drawbar, and not by the frame of trailer.



The New Miami Platform Body Trailer

Miami construction eliminates all torque of frame, as the fifth-wheel will rock on the front axle so that unevenness of ground encountered by front wheels is in no wise distributed to the chassis frame of the trailer. If one creeper wheel of the trailer mounts an obstruction, the frame merely tilts on the front axle without torque.

The trailer is in reality a two-in-one unit, for it can be equipped with either logging bolsters or with a platform body. It is an easy matter to change from platform body to bolsters, or from bolsters to platform body.

The platform body as furnished on the Model CR-21 measures 6 ft. by 12 ft. It can be furnished either with stakes or racks. Racks are built in removable sections to facilitate loading and unloading.

The Model CR-20 Logging Trailer is equipped with two log or lumber bolsters spaced 9 ft. from center to center, with an over-hang as provided for load both front and rear; it will easily handle loads up to 18 ft. in length on single trailers.

The bolsters are each equipped with heavy chock blocks which slide between the channels. The chock blocks are held in position by chains, but are easily removed from the channels for the purpose of inserting skids on the bolster ends for loading logs, oil casings, poles, etc. These trailers are made by the Miami Trailer-Scraper Co., Troy, Ohio.

Barber Asphalt Introduces New Curing Agent

Perhaps one of the most difficult of problems to solve on the concrete paving job is that of curing. When subgrade is right, mix is perfect, and the slab laid down according to all the rules, the success of the pavement is not yet assured. Since strength of concrete depends upon the proportion of water to cement, it is of great importance to preserve the water originally put into the mix, except in those cases where too much was used. Proper curing serves to attain that goal. Again, curing seeks to prevent rapid drying of the surface and consequent crazing that leads to dusting and subsequent disintegration of the slab.

A new curing method has recently been introduced by the Barber Asphalt Co., of Philadelphia, that promises interesting results. Known as Curcrete, intended for use in curing any flat concrete surface, this material is supposed to seal the surface completely at a reasonable cost. This material is an asphalt emulsion that is sprayed on the surface by means of special equipment that has been designed for that purpose. It is applied just after the finishing and remains on the surface until worn off by traffic. As long as it is in place, this material not only assures uniform curing conditions, but has the additional advantages of cutting down dusting and gives the road a surface of pleasing color that is free from glare, according to the manufacturers. The material has been tried out on a number of roads.

Highway Across Mexico.—The government of Mexico plans the completion of a highway completely across the country within a period of four years. The road would connect Mexico City with Laredo, Texas, and with the border of Guatemala.

Blasting a Highway Out of the Side of a Mountain

How 50 Ft. Shelf Was Cut Told in Du Pont Magazine

By A. E. ANDERSON

AFTER the Mount Evans Highway was constructed beyond Echo Lake, which is 50 miles west of Denver, travel became so great that the Bureau of Public Roads decided to build a road from Echo Lake to Idaho Springs, forming a connecting link with another highway.

The rugged character of the mountains in this section necessitated building a switchback road practically all the way down the canyon to the forks of Chicago Creek. From there to Idaho Springs is an old water-grade road which could be easily straightened and widened to make a good highway. But from Echo Lake down the canyon the new roadway had to be cut through the terminal moraine of an old glacier in several places, which made very difficult construction. Immense boulders bedded in water-carrying silt continued to slide down into the excavation during the construction and considerably impeded the progress of the steam shovels.

In several places, too, the workmen had to cut through solid granite cliffs. One of the most difficult of these was at the head of Chicago Creek. This cliff could either be pierced by a tunnel, or a roadway could be cut through along its side by blasting a 50 ft. shelf to make room for it. The latter plan was approved.

The Tunnels for the Blast.—Contractor E. H. Honen drove two tunnels, one from each end of the cliff, along the projected ditch line of the highway as shown in the accompanying diagram. The lower tunnel was shaped like a bent "T," with a 15 ft. arm in each direction. The upper tunnel was 60 ft. deep along the ditch line, with pockets projecting in front of and below the tunnel at 15 ft. intervals. The lower tunnel, with pockets A and B, was about 3½ ft. by 4½ ft. The upper tunnel, with pockets, C, D and E, was about 4 ft. by 6 ft. in section.

Loading the Tunnel.—Since Pyrotol was available at reasonable cost it was decided to use that explosive to throw the mass of material clear off the right of way instead of using black powder, with a percentage of dynamite, at approximately the same cost per pound. One hundred pounds of ammonia dynamite was used with each charge of Pyrotol to insure good detonation. Both electric blasting caps and Cordeau-Bickford fuse, coiled around the pockets, were utilized for detonating agents. An electric cap and primer of dynamite were placed on the inside end of the Cordeau as an extra precaution. Besides placing an electric cap on the end of the Cordeau, two electric blasting caps in 40 per cent ammonia dynamite were placed in each pocket. All of these caps were connected in one series. Double No. 20 wires were used for connecting wires to the mouth of each tunnel. These wires—and the Cordeau fuses also—were wrapped in paraffined box-lining paper, and soft earth was placed around them for protection. Care was exercised to keep the Cordeau straight, except where it was curved around the pockets; this to avoid short kinks. Each cap was tested before it was placed in the charge and frequent tests were made with a galvanometer while the tunnels were being back filled. A rock wall was built up to hold the Pyrotol in place in the pockets, and then the tunnel was back filled with material previously blasted. This was packed securely in place to fill the tunnels completely. It required about two days for this work and one day for loading.

The Arrow Shows the Location of the Upper Tunnel 60 Ft. Deep into the Side of the Cliff and Following the Ditch Line

Across the top of the cliff a line of holes was drilled along the ditch line. They were loaded with gelatin dynamite to help make a clean break for a back slope and all were connected in a series on the line connecting the two tunnels, as indicated in the drawing below.

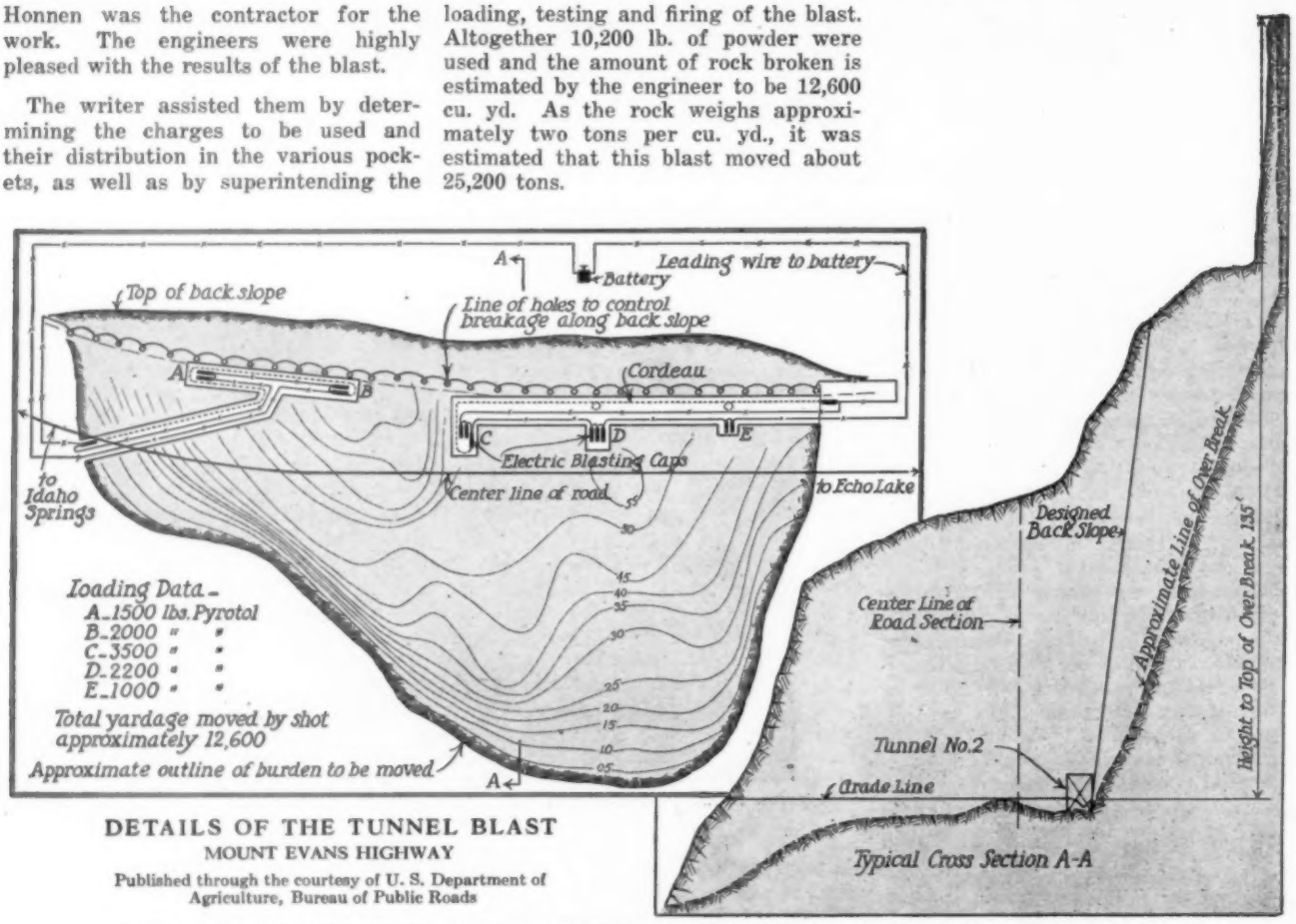
The Electrical Connections.—The electrical connections consisted of one series running through, first, the electric cap on the outside end of the Cordeau; thence, through the pockets and the inside end of the Cordeau up over the top of the hill through the drill holes; down the other side through the inside end of the Cordeau line; through the pockets and out of the second tunnel; and through the cap on the outside end of the Cordeau line. Double lines of No. 14 leading wire were carried from the two ends of the tunnels to a No. 3-A blasting machine on the top of the mountain. The circuit was carefully tested and checked with the galvanometer. The blasting machine, when tested by a rheostat, showed that it would fire 100 holes. About 36 electric blasting caps were connected in this series.

The blast was set off on the afternoon of Nov. 29. It was unusually successful for a blast of this kind and also very spectacular. The estimated burden was 9,100 cu. yd. and practically all of the material was thrown off the right of way. There was an overbreak of about 3,500 cu. yd., back of and above the designed back slope. This could not be avoided on account of slips in the rock, and most of it slid down on top of the road. The contractor was allowed a 10 per cent overbreak, but considering that the blast had thrown clear a larger percentage of material than we expected, he was well pleased; in fact, he described it as the best shot he had ever fired.

C. E. Learned was the associate highway engineer, under J. W. Johnson, district engineer for the Bureau of Public Roads, United States Department of Agriculture. The plans were drawn by C. R. Lugton, resident engineer. E. H.

Honnen was the contractor for the work. The engineers were highly pleased with the results of the blast.

The writer assisted them by determining the charges to be used and their distribution in the various pockets, as well as by superintending the loading, testing and firing of the blast. Altogether 10,200 lb. of powder were used and the amount of rock broken is estimated by the engineer to be 12,600 cu. yd. As the rock weighs approximately two tons per cu. yd., it was estimated that this blast moved about 25,200 tons.



DETAILS OF THE TUNNEL BLAST
MOUNT EVANS HIGHWAY

Published through the courtesy of U. S. Department of Agriculture, Bureau of Public Roads

Sketch Showing Loading Arrangement and Electrical Connections for Tunnel Blast for the Mount Evans Highway in Colorado

New Miami Bulldozer for 2-Ton Caterpillar

The photograph on this page shows the new Miami Bulldozer as manufactured for use with the 2-ton "Caterpillar" Tractor, with the unit pushing a load of dirt over the edge of a fill.

The blade of the Miami Bulldozer measures 6 ft. long by 19 in. wide. It is so mounted on the push arms that it can be tilted either forward or backward at the top to provide the proper plowing action.

The Miami Bulldozer is claimed to be entirely different from any other on the market. It is power operated, with the blade always under the control of the Miami Power Winch mounted on the rear of the tractor, according to the manufacturers. The positive control of the blade through the Miami Power Winch enables the driver to raise or lower the blade instantly without stopping the tractor, it is said, and there is no lost motion. The blade can be raised or lowered as required with the tractor either in forward or reverse motion, while the control of the blade is positive through the power winch as long as the tractor engine is running. The ease with which the blade is controlled through the one lever within easy reach of the operator enables him to complete the work in less time and at a lower cost than with any other similar equipment, it is claimed.

The Miami Bulldozer is strictly a one-man outfit, the entire unit being operated and controlled by the tractor driver, thus eliminating the several men and teams, while the speed of operation saves considerable time. The savings effected by the use of this equipment, the manufacturers say, will enable the owner to pay for it in a very short working period.

There are many uses for the Miami Bulldozer. It can be used in any class of trench or pipeline backfilling work, for grading operations, leveling off dumping grounds, grading roads, pushing dirt over fills, filling in around bridges and foundations, cleaning ore ships and docks and for moving snow.

Miami Bulldozer Pushing Dirt Oven an Embankment

With this unit it is possible, report the manufacturers, to backfill a trench 3 ft. wide by 6 ft. deep at the rate of 100 ft. per hour, moving from 50 to 60 cu. yd. of earth per hour. This outfit is manufactured by The Miami Trailer-Scraper Co., of Troy, Ohio.

County Highway Officials Organize.—Following the national organization of the County Highway Officials through their division of the American Road Builders' Association, the county officials of Delaware and Tennessee have organized state bodies with similar purposes and aims. The new organizations have just been completed with officials chosen from the various counties of those states. Both states will be offered the whole hearted cooperation of the County Officials' Division of the American Road Builders' Association.

Snow Removal in Vermont.—The State Highway Department has approved applications for snow removal from 1,702 miles of the 4,300 miles of the State aid system and is expecting to receive in a short time a few more applications that will fill in gaps here and there. As far as State aid has been secured to date for the plowing of roads, practically all the through lines of traffic are taken care of.

Preparing a Bid

Useful Suggestions Given in Paper Presented March 28 Before New England Road Builders Association

By D. H. DICKINSON
Of Morse & Dickinson, Consulting Engineers, Boston, Mass.

THE object of this paper is not to attempt to lay down any fixed rule for preparing bids but rather to enumerate, and emphasize certain features connected with the bid which may not always receive sufficient consideration by the bidder, or perhaps, are overlooked altogether. Features which in reality occupy an important part in the bid prices of the several items, and may frequently affect the cost to a considerable extent, or at least have a decided bearing upon profit and loss.

Bid Preparation Reliberate Procedure.—The preparation of a bid, in my opinion, should be a somewhat deliberate procedure, and ample time should be allowed so that all the essential facts connected with the project may be ascertained.

In so far as this paper is concerned, we will confine ourselves to the typical state highway job. The prospective bidder is supplied with the usual form of specifications and contract, together with a sheet containing more or less useful, but generally incomplete, information relative to the work, and he is allowed to examine the plan, profile and sections on file at the office of the state department. To my knowledge no arrangement has ever been made for supplying bidders with copies of the plans for their individual use.

Plans.—At this point I wish to call attention to the advantage of securing a complete set of drawings when taking out the specifications. They will prove of great assistance if studied in the field in connection with the proposed work, as it will generally be found that a much clearer idea of the details involved may be had in this manner than would otherwise be possible. They would also be available later for construction use in the case of the successful bidder. It is probable that there would be slight charge for the prints, but the benefits to be obtained would more than compensate for the expense.

Find Out When Survays Were Made.—Before submitting his bid it is advisable for the bidder to ascertain on what date the survey was made. In certain soils, levels taken during the winter months may affect the quantities unfavorably. By actual measurements I have found a variance as great as 6 in. between summer and winter levels taken over the same roadbed. While this difference may be considered a maximum, and even somewhat unusual, it is nevertheless the part of wisdom to take the precaution which I have mentioned.

Furthermore, I recall instances where several years have elapsed between the time that the original cross sections were taken and construction began, and in such cases it is always well when examining the road to determine if possible whether the surface has been graveled in the meantime by the local authorities. This may prove useful information later for the low bidder.

It may seem needless for me to urge you to study the specifications with exceeding care, but those in general use form such a complex document with their usual scattered addenda that it is easy to be mistaken sometimes in regard to their exact meaning. Therefore I feel that this point merits your consideration. Special attention should be given to such features as provisions for handling traffic, whether the road is to be built in half section, and time limit. The personality of the engineer may also receive some justifiable weight.

The Drawings.—These are generally referred to somewhere in the specifications as being supplementary. This gives the party of the first part a double line of attack which is generally taken full advantage of. For this reason the bidder should thoroughly understand the provisions of the design as well as those of the specifications and if any doubt exists it should be dispelled before his signature is affixed.

The plan usually carries but little information of value to the bidder unless an extensive change of alignment is involved. Far more information can be secured from the profile and cross sections, particularly the latter. They are nearly always plotted on a large scale, either four or five feet to the inch, which permits scaling, if desired, with a reasonable degree of accuracy. They show at a glance, extent of cuts and fills, probable length of haul, the relation the new roadway bears to the present one in regard to alignment, grade and contour. They also show dimensions of the paving and subgrade material, ledge outcroppings and other incidental details. In short, any time spent in studying them is in no sense lost.

For several years it has been the custom of the Department to furnish the bidder with an information sheet for each job. This is helpful to a certain extent, but should never be taken at its face value. It is invariably hastily prepared and should be used mainly for the purpose of stimulating individual investigation.

The Unbalanced Bid.—Mention of this topic in a gathering of contractors generally starts the query, What is an unbalanced bid, anyway? I will attempt to answer this by saying that it depends entirely upon conditions, and the individual point of view. A bid which might be so classified by an engineering executive may in reality be a perfectly normal bid, and doubtless would be so considered by the engineer himself if he were acquainted with all the facts that the bidder has in his possession regarding the particular item. For instance, a project may show a large volume of surplus excavation which the enterprising bidder finds that he can dispose of at a profit. He is therefore justified in cutting his price if he so desires, and in so doing he should not be accused of submitting an unbalanced bid. On the other hand, the bidder who takes a chance that a certain item may be materially reduced, or may be eliminated from the contract altogether, and therefore, bids an unreasonably low price can certainly be considered as having submitted an unbalanced bid, and has only himself to blame if he gets stung. This practice is never popular among engineers, and should be avoided for the contractor's own benefit. It too often is responsible for alterations in design, especially by the engineer with overdeveloped trading instincts.

Alterations in Design.—It should be remembered that there is always the prospect of an alteration in design after the work is in progress where the specifications contain this provision, and the prices bid should be such as to carry a reasonable margin of profit in case there should be a considerable increase in any of the various items.

The alteration clause in general use at the present time is highly detrimental to the contractor's interests for the reason that it is an extremely one-sided affair, and while perhaps in many cases its legal import may be doubtful, nevertheless the only action that the contractor can usually afford to take in his own behalf is to enter a vigorous protest against its enforcement. It is an exceedingly tricky clause, and on this account it behooves the bidder to watch his step.

Element of Cost.—Probably no delineation on the subject of bidding can be considered complete without a reference at least to that vital and interesting question, How can a man bid low enough to be in the running, and at the same time be assured a reasonable profit? In my opinion this can be accomplished only through the agency of intelligent and careful bidding by all concerned.

In preparing a bid the element of cost is always of prime consideration. To my way of thinking the main reason why road contracting, one of the biggest industries in the country is not more prosperous is because some of the contractors do not know what their work actually costs item by item, and until costs are known we will continue to have this unhealthy bidding situation based upon the guess formula unsatisfactory to the public, doubly so to the contractor.

The man who bids below cost not only works for nothing and pays for the privilege, but often deprives an-

other of the opportunity to make a fair profit.

Cost Data.—And what about costs? It is not my intention to imply that an intricate force account is always necessary to secure data for this purpose, but there are on every job a few major items like excavation, borrow and broken stone, where cost data could be kept by the timekeeper at no great inconvenience, or expense if desired. But the main trouble with our bidding, I think, is that in our haste we often neglect to include in our reckoning various expenses for which ample provision should be made.

Fixed Charges.—For many years in estimating work it has been my custom to first ascertain as near as possible the actual cost of the various items and then apply the following fixed charges:

1. Premium on bond.
2. Liability insurance.
3. Workmen's compensation.
4. Depreciation on equipment.
5. Interest on investment.
6. Overhead charges.
7. Profit.

In regard to the fixed charges a brief analysis may not be out of place, particularly with reference to overhead, which usually includes the contractor's time, his personal transportation, office expenses, clerical force, legal assistance, taxes, penalties under the contract, uncollectible accounts, interest on borrowed money, and if you can think of any others when making up your bid be sure to include them also.

Monthly Payments.—Most contracts provide for monthly payments to the contractor based upon 85 per cent of the amount of work performed, but the engineer often plays safe at the contractor's expense, and instead of a 15 per cent reserve it is usually much more. This increases with the progress of the job as additional items are included in the estimate, and as delays in making payments for extra work occur. It frequently happens that as much as 25 per cent of the cost of the job is withheld at the date of completion, and unless a portion is released by the bond company at that time it continues to be retained until the expiration of the 65-day period. Interest on the equivalent in borrowed money may amount to quite a sum.

It may or may not be common knowledge that in cases of this kind the state is receiving interest on the contractor's money plus the use of a product which the contractor continues to finance.

In closing permit me to urge that in your next proposal you consider thoroughly the element of actual cost augmented by a full allowance for your own fixed charges. Remembering that the public can well afford to pay a reasonable price for work performed, that the contractor receives neither credit nor thanks for any gratuitous service. And further, that the unwholesome practice of low bidding is harmful both to the business itself, and to the individual, and if persisted in leads to only one inevitable result.

Method and Cost of Removing Concrete End Walls

The Wisconsin Highway Commission recently issued orders requiring the removal of culvert end walls on state and county trunk highways. In Milwaukee County this required the removal of endwalls from 710 culverts and 70 small spans on 220 miles of highway. The device shown in the accompanying illustration was developed by Joseph Schmidler, Construction Superintendent in charge of the work in Milwaukee County.

Device for Demolishing Concrete End Walls

A heavy framework of 4x6-in. timbers, with sway bracing of 2x6-in. plank is built inside the truck body, all members being securely bolted together. The end bents are bolted to the front and rear gates to insure rigidity. On this frame work is bolted, and blocked to prevented side motion, a 6x8-in. timber which runs diagonally across the top and extends about 4 ft. beyond the right rear of the truck about 14 ft. above the ground. From this diagonal member, a cast iron ball weighing 1,250 lb. is suspended on a heavy chain. The angle of this diagonal member is such that when the truck is driven alongside of the culvert endwall the suspended weight is very nearly in contact with the wall.

Four men, by pulling on a rope, cause this ball to swing as a pendulum and, acting as a hammer, this moving weight shatters the concrete. This is kept up until the wall is demolished. Reinforcing steel, when exposed, is cut with a hardie although a torch could be used to good advantage. After demolition has taken place, the rough tops are trimmed with air chisels, although in a great number of cases breakage is uniform and this is unnecessary.

The weight is set so as to deliver the first blows at 6 to 8 in. from the top, it having been found that by so doing a line of cleavage develops at the first horizontal reinforcing bar, usually about 12 in. from the top. The weight can be lowered by raising the front end of the truck body until the ball rests on the ground and then lengthening the chain. It is inadvisable to use the weight with the body in a raised position because of the unusual strains which are set up. An "A" frame was first used at the rear end but it could not be braced properly and furthermore it was found that considerable force was lost because of the arc in which the hammer traveled when it passed the center of the truck.

Contrary to general opinion, very few cracks have been developed in culvert barrels by the use of this outfit. A little experience will soon show in just what manner an endwall can best be removed. For example, for a culvert with an endwall which extends a considerable distance above the barrel opening with little or no earth pressure to take up the shock, the truck should be backed up so that the weight is on the outside of the endwall and the blows should be struck from the field side.

According to April Badger Highways in a little more than two months, by means of this simple but effective apparatus, 1,560 endwalls have been removed at an average rate of 35 per day. The cost including machinery rental, labor and supplies for each endwall, was 98 cts.

Dragging Gravel Onto Roads at Intersections

In a paper presented at the recent Purdue Road School, A. H. Hinkle, Superintendent of Maintenance of the Indiana State Highway Commission, calls attention to the need for more careful dragging of county roads at intersections with the state gravel highway. At this point a high place is frequently found, which is sufficient to produce quite a bump to the high speed traffic going over it.

Mr. Hinkle states that an examination into the cause of the building up of these high places, shows that they are principally caused by the drags or graders used on the crossroads being turned at the intersection and permitting the loose gravel in front of the blades to be deposited upon the state road. Frequently this gravel contains sod and silt from the roadside which acts as a binder and causes the loose material to "set up" quickly. This is done many times during the year at an intersection and results in building up a high place in the state road which can not always easily be cut down, and if cut down to the proper grade soon appears again from succeeding draggings.

Smooth and Rough Texture Asphalt Surfaces

Relative Advantages Discussed in Paper at 6th Annual Asphalt Paving Conference

By ARTHUR H. BLANCHARD
Consulting Highway Engineer, Toledo, O.

THE economics, construction, maintenance and characteristics of the surfaces of bituminous pavements have been under consideration and discussion in the United States for about 60 years.

The Abbot Patent of 1873.—By a review of the literature of the seventies, it is practicable to ascertain the status of the problem in the minds of the paving technologists of that period. Only one reference will be cited. The following abstract is from a book, by N. B. Abbot, published in 1876, entitled "Bituminous Concrete Pavements as Laid in the United States."

"It is the practice of most of the concrete pavement men to finish the surface with a top dressing of dry sand, rolled into the surface; or of hydraulic cement, swept in with a broom. I became early satisfied that some better plan of finishing was needed. The most compact concretes are more or less porous on the surface; and though these pores are filled with the sand or cement used for top dressing, neither of these materials being waterproof, in wet weather the water penetrates the pavement, street dirt mingles with the water, and a disintegrating process begins, which soon results in breaks and unevenness of surface. In winter, particularly, the moisture, having penetrated the pavement, freezes and thaws, and decay is hastened. It is just as essential that a concrete pavement should be waterproof as that a roof should not leak. My experiments in this direction resulted in what is known as the Abbot Grit Surface, which was patented June 17, 1873. This improvement consists in spreading a hot liquid composition over the surface of the pavement after it is rolled, into which is placed clean, dry grit or sand. This sand is immediately rolled into the surface while the composition is warm, and a tough coating is thereby formed, which not only prevents the pavement from being slippery, but effectually closes every pore in the surface, and makes it impossible for moisture to penetrate."

Abbot stressed two important characteristics which are today considered in the design of asphalt surfaces, namely, imperviousness and non-slipperiness. He described a method of constructing a seal coat on a bituminous concrete pavement which is successfully utilized in modern practice.

Although since the days of Abbot many methods of constructing asphalt surfaces have come into vogue and the character of the traffic on highways has undergone a marked change, the fundamental principles underlying the Abbot patent of 1873 constitute basic factors in the paving practice of 1927.

Classification of Asphalt Surfaces.—In considering the subject of this paper from the viewpoint of the practice and problems of today, it appears advisable to have a picture of what constitutes a smooth asphalt surface and what is meant by a rough texture asphalt surface As both smooth and rough are relative terms, naturally there will arise disagreement over the classification of several types of asphalt surfaces. To definitely define either of these types of surfaces is as difficult as drafting a definition of common carrier in the field of highway transport. However, it is believed that there will be general agreement in stating that the European rock asphalt pavement surface is smooth and that the surface of an asphaltic macadam pavement finished with a seal coat of asphaltic cement and ¾ in. stone has a rough texture. Between these two types of surfaces, many variations are found, especially those characteristics of asphaltic concretes and asphaltic macadams.

The query naturally arises as to the reason for different types of surfaces for a given kind of asphaltic pavement. It is believed that these differences are due to a major consideration by the designing engineer of one or more of the following factors: imperviousness, density of the upper layer of the wearing course, non-slipperiness, durability, first cost, maintenance cost, availability of materials or equipment, and suitability for the traffic and local conditions. As included under suitability for the traffic to which the pavement is to be subjected, may be mentioned tractive resistance and tire wear.

The kind of asphaltic pavement selected for a given location may or may not be dependent upon the type of surface. While there may not be much difference in sheet-asphalt pavement surfaces, from the standpoint of texture, it is practicable to complete most kinds of asphaltic concretes and asphaltic macadams with any type of surface desired.

The types of surfaces of asphaltic pavements may be classified under two general groups.

First, those having a suface subjected to traffic composed of the surface of the wearing course.

Second, those having a surface subjected to traffic formed by the application of a seal coat to the wearing coarse.

The surfaces of the second group generally may be further subdivided into two classes:

First, surfaces constructed with seal coats of asphaltic cement followed by the application of a covering of sand, crushed stone or slag, or other fine material.

Second, surfaces constructed with seal coats of precoated fine aggregate, with or without the application or other fine material.

From the standpoint of any one of the factors which may be considered in deciding upon the type of surface to adopt, it is practicable to compare two or more types for a given location and set of conditions. It is impracticable, however, to satisfactorily compare types of surfaces from a general standpoint due to the many variables entering into the problem.

Rather than enter into a detailed discussion of the relative advantages of different types of asphalt surfaces from the standpoint of the many factors involved, the writer, both from the viewpoint of an engineer and one deeply interested in highway safety, considers it advisable to utilize the limitations of this paper for a discussion of one important factor.

The Standpoint of Relative Slipperiness.—Considerable discussion of the relative advantages of smooth and rough texture asphalt surfaces has been due to a consideration of different types from the standpoint of relative slipperiness. The conclusion that non-slipperiness is a pavement characteristic of prime importance is generally accepted. Non-slipperiness of a roadway, however, is not dependent wholly upon the character of the pavement surface. Contributing factors will be mentioned later.

The slipperiness of pavement surfaces is now before the public to a greater degree than ever before because of the millions of vehicular operators, the general interest in the causes of highway accidents, the publicity given to accidents resulting in material property damages, injuries and fatalities, and the many campaigns under way to promote highway safety.

In connection with the consideration of slipperiness factors, it is of interest to diagnose typical highway accidents statistics.

In accident reports, the term skidding is used to designate an accident due to the vehicle slipping sideways on the roadway surface and also to the vehicle sliding forward without a sideways movement.

Causes of Motor Vehicle Accidents.—Does skidding occur to an extent which warrants special attention being given to it by paving technologists and highway officials?

In "Accidents Facts—1927," published by the National Safety Council, information is given relative to the circumstances of accidents based on reports made to the Council under the Standard Accident Reporting System, which will be referred to later. It is recorded that out of the of total of 112,790, in 1926, 5,727, about 5 per cent, were due to skidding.

More detailed information is obtainable from State reports. As an example, those of the State of New York have been selected. Its Motor Vehicle Bureau has adopted the Standard Accident Reporting System. In connection with the problem of skidding, interest naturally centers on the data supplied relative to the road and climatic conditions. The character of information requested in the case of the following items is indicated by text printed in parentheses below the lines for the answers.

Character of road: Curve, up-grade, down-grade, street intersection, railroad crossing, bridge, culvert, straight.

Road surface: Wet, dry, mud, ice, sand.

Weather conditions: Fog, mist, rain, snow, clear.

Information requested relative to cause of accidents, traffic density, speed, and if the accident was due to any mechanical defect, is also of value in connection with the consideration of skidding.

In 1925 this Bureau reported 58,444 motor vehicle accidents of which 2,752 were attributed to skidding.

The condition of the road surface was reported in 45,892 cases as follows: Dry, 34,752; wet, 9,051; muddy, 124; snowy, 873; icy, 1,092.

Weather conditions were reported in 45,873 cases as follows: Clear, 36,501; cloudy, 2,171; fog, 419; rain, 6,046; snow, 736.

It is thus seen that it is practicable to presuppose that the vast majority of the skidding accidents occurred under the conditions of roadway surface usually considered as being contributory causes of skidding. This conclusion is further substantiated by an analysis of the data for a winter month. In January, 1926, of 2,547 accidents attributed to motorists, 768, about 30 per cent, were reported as due to skidding.

Further evidence in this connection is furnished by the results of investigations at Iowa State College. It is reported that "these experiments, using pneumatic tires on various road surface conditions, show that on roads coated with snow or ice or oily slime or mud, the force required to cause skidding is approximately one-third to one-fourth of that on clean, dry surfaces; while on icy roads, that are thawing a little, the coefficient may be as low as one-sixth that on a clean, dry surface.

When Skidding Occurs.—Based on the results of investigations, conferences with engineers, highway officials and motorists, and personal research, it is believed that the amount of skidding may be attributed to the conditions of the pavement surface in the following order, the most unsatisfactory condition being mentioned first.

1. Icy surfaces that have thawed slightly.
2. Surface coated with ice, hard, compacted snow, mud, or a comparatively light covering of dust or dirt during the period following the beginning of rain or when there is a heavy fog or mist.
3. Surfaces which are wet but clean.
4. Surfaces which are clean and dry.

From accidents statistics, as previously indicated, it is practicable to deduce general conclusion relative to roadway surface characteristics as indicated in the four classifications cited, but it is not practicable from this source of information to draw conclusions pertaining to relative slipperiness in each of the four groups. It is believed that this statement will be readily accepted when consideration is given to the varying amount of traffic on different pavements, difference in climatic conditions, etc., in a given area covered by a reporting bureau.

Current accidents reports give little, if any, information relative to the type of pavement upon which an accident occured. The Standard Accident Reporting System does not include this item. Without doubt, those respensible for drafting the standard form presupposed that the average layman has not sufficient knowledge relative to different kinds of pavements to warrant the assumption that he would be capable of giving correct information pertaining to this item. Of course, information would be obtainable if a paving engineer visited the location where accidents occurred. Investigations made by the writer indicate that under contributory conditions skidding occurs on all types of pavement and road surfaces.

It is incumbent upon highwary officials and engineers to give consideration to the causes of skidding accidents. In this connection the query naturally arises as to the number of accidents due to the improper operation of motor vehicles. Unfortunately definite information generally is not obtainable from accident reports. Investigations indicate, however, that a large percentage of skidding accidents are due to improper operation. This is due in part to carelessness, but it is believed it is also due to ignorance of proper methods of operation under varying conditions of surface previously enumerated. The writer has found several conditions on different types of pavement when it is impracticable to operate at a speed exceeding ten miles per hour and in some cases at more than seven miles per hour. When the amount of traffic using the highway and the average speed of operation are considered, it is not surprising to find many accidents due to skidding. The average operator does not appreciate the distance required in which to stop a motor vehicle under the varying conditions of roadway surfaces previously cited.

There is now available reliable information relative to certain phases of this problem. Based upon comprehensive investigations and tests of a large number of motor vehicles, primarily made by the U. S. Bureau of Standards, the Sectional Committee on Safety Code for Brakes and Braking Testing presented the following recommendation which was adopted by the parent body, the American Engineering Standards Committee.

In case of all motor vehicles weighing 6,000 lb. gross or less, on a dry, hard, level road free from loose material, the foot-brake shall be capable of stopping the vehicle from a speed of 20 miles per hour within a distance of 50 ft.

When the elements of this practical recommendation are considered in connection with the results of the Iowa State College investigations, which indicated that the force required to cause skidding under certain surface conditions might be as low as one-sixth that on a clean, dry surface, it is not surprising to find that many skidding accidents are due to the operation of motor vehicles at excessive speeds.

It is believed that a campaign to inform motorists as to the conditions under which skidding is liable to occur and proper methods of operation of motor vehicles under such conditions would result in a material reduction of skidding accidents. Such bodies as the National Safety Council, the Commitee on Causes and Prevention of Highway Accidents of the Highway Research Board, the American Road Builders' Association, the American Association of State Highway Officials, the American Automobile Association, the National Automobile Chamber of Commerce and the National Highway Traffic Association could render valuable service in this connection.

The relative advantages of smooth and rough testure asphalt surface under various conditions of use is worthy of study and research by a group of specialists. It is suggested that a committee of the Association of Asphalt Paving Technologists be appointed to investigate and report on this subject.

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7 Years of State Highway Work in New York

New construction and reconstruction contracts on the state highway system let during the past 7 years by the New York State Division of Highways cover a total mileage of 4,163. The following table, from The Low Bidder, showing the mileage by years bring out quite clearly the increased amount of reconstruction that is being undertaken:

Year	New Construction Miles	New Construction Cost	Reconstruction Miles	Reconstruction Cost
1921	616	$22,161,801	167	$ 3,671,043
1922	497	16,245,090	108	2,548,845
1923	187	8,291,757	169	6,260,108
1924	316	13,463,468	234	9,986,441
1925	369	16,474,782	291	11,940,704
1926	284	13,763,034	256	12,602,773
1927	312	16,242,373	357	19,787,836

MOTOR-VEHICLE REGISTRATIONS, 1927[1]

[Compiled from reports of State authorities]

State	Registered motor vehicles, individually and commercially owned[2]			Other registered vehicles		Tax-exempt official motor cars and motor cycles			Number of licenses or permits (autos)			Total registered motor cars and trucks, 1926	Year's change in motor-vehicle registration		State
	Total registered motor cars and trucks	Passenger automobiles, taxis, and busses	Motor trucks and road tractors	Trailers[3]	Motor cycles	United States cars	State and local cars	Motor cycles (official)	Dealers	Operators	Chauffeurs		Number increase or decrease (−)	Per cent	
Alabama	243,539	211,633	31,906	1,472	420	167			3,919		1,630	225,930	17,609	7.8	Alabama.
Arizona	81,047	70,802	1,345		371	176	816		212	400	401	73,682	7,365	10.0	Arizona.
Arkansas	206,568	174,534	32,044	1,977	303	39	736	21	479		4,932	209,419	−(2,851)	−1.4	Arkansas.
California	1,693,195	[4] 1,479,411	[5]213,784	34,126	9,444	1,217	[6]23,214	481	3,270	129,792	111,193	1,600,475	92,720	5.8	California.
Colorado	268,492	245,107	23,385	88	1,362	263						248,613	19,879	8.0	Colorado.
Connecticut	281,521	238,509	43,012	150	3,063	71	2,459	281	5,600	[6] 323,681		263,285	18,236	6.9	Connecticut.
Delaware	47,124	38,037	9,087	313	343	44			438	[6] 51,945		44,534	2,590	5.1	Delaware.
Florida	394,734	332,979	[7] 61,755	[7] 1,000	1,243	75	3,451	206	2,547		4,949	401,562	−(6,828)	−1.7	Florida.
Georgia	300,635	262,630	38,005		909	934			792		2,553	277,468	23,167	8.4	Georgia.
Idaho	101,330	91,300	10,030	186	440	103	1,210		406		476	94,760	6,576	6.9	Idaho.
Illinois	1,438,985	[4] 1,254,421	184,564	3,480	6,135	979	(9)		4,594		100,398	1,370,508	68,482	5.0	Illinois.
Indiana	813,637	697,350	116,278	6,900	3,000	3,184	4,063		2,544		99,212	777,338	41,311	5.3	Indiana.
Iowa	704,205	648,309	54,894	170	1,767	44	2,827		2,531	2,964		696,998	5,205	.7	Iowa.
Kansas	501,901	447,273	54,628		1,118	192	2,360		2,525			491,376	10,525	2.2	Kansas.
Kentucky	285,631	255,862	29,729		633	90	1,742	59	1,051		5,410	281,557	4,064	1.4	Kentucky.
Louisiana	255,000	216,000	39,000	3,500	510	209			487		14,177	239,500	15,500	6.5	Louisiana.
Maine	165,623	132,927	30,656	1,012	1,245	84	1,173	66	1,297	188,975	7,309	151,486	12,137	8.0	Maine.
Maryland	270,015	265,769	5,167	616	2,415	1,969	940		6,788	33,814	40,679	252,852	18,063	7.1	Maryland.
Massachusetts	694,107	614,359	79,748	443	7,245	558	800		2,043	122,285		690,190	3,917	.6	Massachusetts.
Michigan	1,154,773	[4] 988,781	[4] 155,992	17,853	3,555	371	(9)		2,128	220,954	76,483	1,118,785	35,988	3.2	Michigan.
Minnesota	646,682	565,401	81,281	3,286	2,295	252	2,450		2,087		17,988	630,256	16,397	2.6	Minnesota.
Mississippi	218,043	196,239	21,804	2,317	83	74			656			205,200	12,843	6.2	Mississippi.
Missouri	682,419	610,303	72,116	1,739	1,835	311	1,428	3	2,387	5,230	28,269	654,584	27,835	4.2	Missouri.
Montana	112,735	94,753	18,002		156	229	1,158	9	481		338	103,958	8,777	8.4	Montana.
Nebraska	373,912	[4] 342,357	[4] 31,555	1,528	1,109	226	1,029		3,052			366,773	7,139	1.9	Nebraska.
Nevada	25,776	20,414	5,362	104	99	42			533			24,014	1,762	7.3	Nevada.
New Hampshire	96,009	83,415	12,594	565	1,387	22			541	73,474	43,242	88,001	7,008	7.9	New Hampshire.
New Jersey	712,396	586,510	125,886	1,827	6,857	768	6,294	913	2,917	814,593	6,422	651,415	60,981	9.4	New Jersey.
New Mexico	59,261	57,643	1,618	183	170	158	530		170			54,996	4,265	7.8	New Mexico.
New York	1,937,918	1,624,535	313,383	6,936	16,347	1,656	12,116	1,262	4,482	1,701,383	616,025	1,815,434	122,484	5.7	New York.
North Carolina[2]	[4] 430,499	390,223	40,276	1,618	1,194	429	5,419		6,330			[8] 385,047	45,452	11.8	North Carolina.
North Dakota	160,701	144,830	15,871		277	3						157,822	2,879	1.8	North Dakota.
Ohio	1,570,734	1,374,402	196,332	12,134	7,749	2,362	9,067		20,997			1,480,245	90,489	6.1	Ohio.
Oklahoma	503,126	437,776	65,350		1,200	530						499,938	3,188	.6	Oklahoma.
Oregon	244,573	223,862	20,990		2,030	141	1,132		694	59,355	13,709	233,568	11,004	4.7	Oregon.
Pennsylvania	1,554,915	1,354,548	200,367	3,780	14,267	1,263	942		28,147	1,564,161		1,455,194	99,721	6.9	Pennsylvania.
Rhode Island	118,014	98,861	19,153	57	1,250	56	671	87	300	136,960		110,746	7,268	6.6	Rhode Island.
South Carolina	190,635	179,571	20,064	1,387	335	91			508			181,189	18,446	10.2	South Carolina.
South Dakota	169,552	153,019	16,533		229	85	1,019					168,230	1,322	.8	South Dakota.
Tennessee	294,567	269,086	25,481	(9)	904	132	2,914		632			279,639	14,928	5.3	Tennessee.
Texas	1,111,407	996,397	115,010	9,826	3,061	2,565			3,323	41,775	11,460	1,040,969	61,536	5.9	Texas.
Utah [4]	93,976	80,731	13,245		531	173						85,380	8,596	10.1	Utah.
Vermont	78,527	73,308	5,219		601	28			656			74,063	5,464	7.4	Vermont.
Virginia	337,607	288,666	48,941	496	2,025	1,141		253	2,950		6,450	322,614	14,993	4.6	Virginia.
Washington	384,583	336,667	57,916	2,072	2,501	837	4,682	144	4,579	397,975		363,279	21,304	5.9	Washington.
West Virginia	245,819	217,689	28,130	392	1,431	33	1,862		13,701	61,600	25,200	227,836	17,983	7.9	West Virginia.
Wisconsin	696,289	630,795	65,494		2,963	92	668	79	2,949			662,262	34,027	5.4	Wisconsin.
Wyoming	51,955	45,539	6,416		134	209	257		306			49,883	2,072	4.2	Wyoming.
District of Columbia	111,680	98,162	13,518		1,151	837	2,131	212	1,958	57,014	1,581	111,497	183	.2	District of Columbia.
Total	23,127,318	20,230,429	2,896,889	123,451	120,300	[11] 33,179	101,089	4,056	155,444	5,948,430	1,185,570	22,001,393	1[1]25,922	5.1	Total.

[1] All States report for calendar year except North Carolina which reports only 6 months totals (July 1 to Dec. 31), as their fiscal year for registration ended June 30.

[2] The first 3 columns record the regularly registered motor cars and trucks which pay the regular license fees eliminating reregistrations and registration of cars owned by nonresidents. Some States, as noted, classify busses with trucks. Tables showing the extent and kinds of bus service (from nongovernment sources) can be found in the February, 1928, issue of "Bus transportation."

[3] Some States include trailers with motor trucks, other States do not register trailers

[4] Busses included with trucks.

[5] Includes over 8,000 cars and trucks of public-service corporation exempt by law

[6] Includes chauffeurs.

[7] Trailers (1,000 estimated) excluded from trucks.

[8] Official cars included in first 3 columns as $2 fee charged.

[9] Last six months of year's registration only as year commenced July 1.

[10] Preliminary data, subject to revision

[11] As reported in 1925 by Bureau of Budget, and includes 7,959 "Cars-at-large," not allocated to any State.

GASOLINE TAXES, 1927

Total taxes earned on motor-vehicle fuel, etc., refunds, disposition of funds, and gallons taxed

[From reports of State authorities]

State	Gross tax assessed prior to deduction of refunds	Exemption refunds: (Deducted from gross tax)	Total tax earnings on fuel for motor vehicles[1]	Other receipts under tax law (licenses)	Grand total earnings (tax and other receipts)	Disposition of grand total earnings					Tax rates, 1927			Net gallons of gasoline taxed, and used by motor vehicles
						Collection costs[2]	Construction and maintenance on rural roads		State (S) and county (C) road bond payments	Miscellaneous purposes	Cents per gallon		Date of rate change	
							State highways	Local roads			Jan. 1	Dec. 31		
Alabama	$5,908,986		$5,908,986		$5,908,986	$28,542	$2,616,865	$2,962,829	(S) [3]$303,750		2	4	Jan. 25	140,620,507
Arizona	1,646,375	[4]257,545	1,388,830		1,388,830			620,091			3	4	Aug. 12	40,216,027
Arkansas [5]			4,336,737		4,336,737			1,041,297	564,036	[6] 2,733,404	4	5	June 9	[6] 94,245,530
California	24,453,583	1,986,502	22,467,082		22,467,082	41,762		13,158,714	9,266,607		2	3	July 29	928,748,702
Colorado	3,272,537	132,943	3,139,594		3,139,594	21,221		2,160,745	957,628		2	3	May 1	122,460,107
Connecticut	3,054,908		3,054,908	$42,322	3,097,428	(9)		3,097,428			2	2		152,745,302
Delaware	681,468	19,307	662,159		662,159	(9)		662,159			2	3	Mar. 24	23,486,804
Florida	10,980,586		10,980,586	27,855	11,008,441	2,800		7,552,018	2,513,491	[10] $940,322	4	5	July 1	251,410,061
Georgia	7,068,109		7,068,109	11,394	7,077,503	4,200		[11] 709,581	1,910,833	[12] 353,889	3½	4	Sept. 1	192,103,248
Idaho	1,669,057	97,308	1,571,749		1,571,749	11,966		436,096		[13] 123,687	3	4	Mar. 1	40,876,736
Illinois [14]	6,248,009	48,500	6,199,509		6,199,509	25,000		097,255	[15] 3,087,254	(15)(C)	0	[16] 2	Aug. 1	309,975,406
Indiana	10,400,307	366,739	10,133,568		10,133,568	15,164		[11] 745,580	2,526,596	[15] 843,196	3	3		337,709,317
Iowa	7,612,106	363,892	7,248,214		7,248,214	57,755		1,833,000	3,656,000	[17] 1,691,459	2	3	July 4	288,619,674
Kansas	5,081,617	486,967	4,594,650		4,594,650	(17)		3,850,720	743,930		2	2		220,732,510
Kentucky	5,913,396		5,913,396		5,913,396	11,700		5,901,696			5	5		118,267,918
Louisiana	3,034,056		3,034,056		3,034,056			3,034,056			2	2		151,702,807
Maine	2,344,347	55,414	2,288,933		2,288,933	12,952		2,275,981			3	4	Oct. 29	[18] 72,027,253
Maryland	4,314,297	144,900	4,169,397		4,169,397	2,500		2,973,436		[19] 1,193,461	3	4	Apr. 1	118,335,211
Massachusetts	No tax.										0	0	No tax	(20)
Michigan	15,327,752	1,067,158	14,260,564		14,260,564	43,797		5,409,937	2,808,830	(S) 3,000,000	2	3	Sept. 4	561,144,507
Minnesota	5,510,257	335,377	5,174,880		5,174,880			5,174,880			2	3		206,743,986
Mississippi	[21] 4,890,686		4,890,686		4,890,686	3,600		2,302,347	2,378,311	[22](C) 206,428	4	4		119,342,686
Missouri	6,440,955	118,672	6,230,983		6,230,983	48,488		6,282,495			2	2		316,549,141
Montana	1,601,621	165,223	1,436,398		1,436,398	(23)		1,436,398			2	2		67,879,027
Nebraska	3,685,218	20,309	3,664,919		3,664,919	8,013		3,656,906			2	2		183,245,970
Nevada	509,936	38,312	471,624		471,624			235,812	235,812		2	4		11,790,615
New Hampshire	1,291,499	22,592	1,268,907		1,268,907			1,268,907			2	[24] 3	May 1	44,897,901
New Jersey	4,775,137	692,277	4,082,860	15,125	4,097,985	25,000		3,982,985		[25] 90,000	0	2	July 1	204,142,900
New Mexico	1,415,690		1,415,690	18,502	1,434,192	30,975		1,203,217	(S) 100,000		3	3	Mar. 7	70,117,191
New York	No tax.										0	0	No tax.	(20)
North Carolina	9,111,207	324,615	8,786,592		8,786,592	[26] 47,286		[26] 6,444,313		[26](S)2,295,081	4	4		219,907,000
North Dakota	1,673,633	208,068	1,275,565	$88	1,276,423	25,000		1,210,000		[25] 41,423	2	3		63,778,243
Ohio	20,475,655	565,207	19,910,681		19,910,681			11,998,452	7,912,029		2	3	May 25	732,028,004
Oklahoma	7,224,276	26,320	7,197,956		7,197,956	(9)		4,798,637	2,399,319		3	3		299,931,866
Oregon	3,870,393	726,202	3,643,191		3,643,191	8,386		3,634,805			3	3		125,822,563
Pennsylvania	17,296,533		17,296,533		17,296,533			13,836,523	3,457,810		2	3	July 1	691,562,015
Rhode Island	915,939		915,939		915,939	(9)		736,447		(S) 179,512	1	2	June 1	58,144,667
South Carolina	5,086,899	6,514	5,080,385		5,080,385	5,000		3,045,231	1,822,616	(C) 507,538	5	5		101,607,700
South Dakota	3,074,585	641,063	2,393,522		2,393,522	4,760		2,074,660		(S) 242,243 [25] 71,920	3	4	July 1	45,908,089
Tennessee	4,476,180		4,476,180		4,476,180			4,476,180			3	3		149,206,016
Texas	15,650,841		15,650,841		15,650,841			11,738,131		[25] 3,912,710	1	3	Mar. 16	594,562,077
Utah	1,461,261		1,461,261	$38	1,461,299	5,373		943,814		(S) 512,300	3½	3½		41,771,659
Vermont	905,244		905,244		905,244			905,244			2	3	June 1	52,167,246
Virginia	7,515,839	$76,152	7,139,707		7,139,707			4,758,805	2,379,902		4½	[27] 4½		158,423,951
Washington	4,086,891	265,453	3,821,438		3,821,438	[28]		3,821,438			3	3		191,071,925
West Virginia	3,807,644	103,570	3,704,068	13,254	3,807,322			3,807,322		[29] (S)	3½	4	July 1	99,917,717
Wisconsin	6,271,738	244,624	6,027,114		6,027,114	8,982		2,214,899	3,368,279	[30] 433,954	2	2		301,355,684
Wyoming	756,049		756,049		756,049	3,687		752,362			2½	3	Mar. 1	25,884,303
District of Columbia	1,156,104	7,310	1,148,794		1,148,794					[31] 1,148,794	2	2		57,439,721
Total			256,838,813	128,638	258,908,851	499,933	182,095,503	55,440,161	10,086,456	10,844,708	Aver. 2.76			[32] 9,386,651,89[2]

[1] This is the net tax after deduction of refunds because of exemptions.

[2] Collection costs in many States are paid from other State funds and when amounts and sources are reported notes are entered below.

[3] On State highway bonds, series O only.

[4] Tentative data, as accounts are to be audited.

[5] Includes $216,987 on State highway bonds and $2,516,467 on local road bonds.

[6] Estimate based on rates and amounts received.

[7] Excludes $31,547 from gasoline inspection fee fund.

[8] Approximately $46,000 charged to motor vehicle department.

[9] Approximately $60 charged to State treasury.

[10] For free public school fund $616,135; for permanent building fund $208,057; and balance of $16,140 in State treasury.

[11] For State treasury.

[12] Unalloted balance.

[13] Earnings for last 5 months of year only.

[14] County bond payments included in local road allotments.

[15] Tax discontinued Feb. 28, 1928.

[16] For city streets.

[17] Special refunds for rights of way and bridges.

[18] From State general fund.

[19] Includes 2,770,706 gallons not consumed by motor vehicles but taxed 1 cent per gallon.

[20] Baltimore city $745,042; grade crossing elimination $430,439.

[21] Estimated consumption based on motor-vehicle registration, 310,000,000 gallons.

[22] Includes $131,306 from extra tax in Harrison and Hancock counties for sea wall to protect State highway.

[23] Sea-wall bonds.

[24] State appropriation of $12,000.

[25] Gasoline tax became 4 cents on Jan. 1, 1928.

[26] For Department of Commerce and Navigation.

[27] Estimated consumption based on motor-vehicle registration, 930,000,000 gallons.

[28] Allocation of fund estimated.

[29] General State fund.

[30] State appropriation of $5,700 from general revenue.

[31] State appropriation of $5,000.

[32] Reserve for refunds.

[33] For free school fund.

[34] Increased to 5 cents on Mar. 19, 1928.

[35] From motor vehicle fund, $5,000.

[36] Payments on State road bonds charged to gasoline fund; amount not stated.

[37] For city streets.

[38] Receipts expended on Washington streets for improvement and repairs.

[39] For approximate total of all States, add estimated amounts given in notes 21 and 27 for Massachusetts and New York to total here given and also add 530,000,000 for untaxed gasoline in Illinois and New Jersey, making a grand total of 11,130,000,000.

New Trade Publications

The following trade publications, of interest to highway officials, engineers, and contractors, have been issued recently. Copies of them may be secured upon request to the manufacturers named.

Vibrolithic Pavement.—The American Vibrolithic Corporation, Des Moines, Iowa, have issued an interesting illustrated booklet entitled "Armor-plated Compressed Concrete Pavement." This booklet tells in picture form how the various steps were accomplished in paving Sheridan Road, Chicago, by their "Armorplated" method. By this method a carefully mixed concrete is laid on the subgrade, the surface is covered with a layer of crushed stone, their vibration mats are put on the surface, the concrete is then vibrated with their machines until a dense slab is formed with the stones completely embedded, and the surface is then rolled and troweled and finally covered with a film of silicate of soda as a curing agent. The booklet tells an interesting story, describing the methods used under this interesting process in an effective manner.

Truckloaders.—George Haiss Mfg. Co., New York City, have issued a new bulletin describing their Haiss Fordson Bucket Loaders and their Traxion Chassis for the Fordson tractor. These machines are said to be adapted to a variety of work, and are completely described in the bulletin.

Tar.—The Barrett Company has issued a novel cutout folder shaped like a distributor truck, that tells the story of Tarvia service, and tells it briefly.

Mixers.—The T. L. Smith Company of Milwaukee, manufacturers of Smith Mixers and Pavers, are distributing a new 72-page catalog covering their full line. Included in the catalog are eleven full-page views in color showing Smith Mixers in service on some of the outstanding construction projects, such as the Cascade Tunnel, Jordan Dam, Goodrich Tire Plant, Exchequer Dam, Chicago Sewage Disposal Plant and the Memorial Bridge at Gadsden, Alabama. Other pages are devoted to the description of the various sizes from the small 2½ cu. ft. mixer to the world's largest mixer with a batch capacity of 4 cu. yd. The patented Smith End-to-Center Mixing Action is fully described as are the other structural advantages. Attention is called to the 28 years of experience of this company in building nothing but concrete mixers and pavers.

Road Machinery.—The Galion Iron Works & Mfg. Co., Galion, Ohio, have issued a new catalog showing their complete line of road machinery. While it shows the entire line and gives a lot of pertinent information on each machine, the user is urged to apply for more detailed information that is available.

Power Shovels.—The Thew Shovel Company, Lorain, Ohio, has issued a new folder presenting the message that during 1927 only one in 228, or a total of 159 center drive truck shoes were replaced out of the 36,000 in service. Similarly, the folder states, only 1 in 103 or a total of 704 thread pins were replaced out of the 72,600 in use. The message of the folder is one of dependable service claimed for the Lorain 75 and the Lorain 60.

Road Machinery.—The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, has issued three new folders that are of interest. One describes their Contractors' Special elevating grader, another illustrates their portable crushing and screening plants, while the third tells about their new patrol graders.

Industrial Locomotives.—George D. Whitcomb Company, of Rochelle, Ill., has issued a new bulletin telling about their gasoline engine powered industrial locomotives ranging in size from 10 to 30 tons. Complete specifications are included. This bulletin contains a great deal of interesting information.

Motors.—"Continental Red Seal," the house organ of the Continental Motors Corporation, is an interesting little magazine. The May issue has been distributed, and contains information of interest to gasoline motor users. A new standard list of service charges is published in that issue.

Road Building Machinery.—C. D. Edwards Mfg. Co., Inc., of Albert Lea, Minn., has issued an interesting 50th anniversary catalog showing their road graders, patrols, rotary snow plow, plows, drags, fresnos, scrapers and other road maintenance equipment.

Power Shovels, Cranes, Etc.—Link-Belt Company, Crane and Shovel Division, 300 W. Pershing Road, Chicago, in a recent issue of their interesting house organ, "Link-Belt Shovel News," show a number of difficult jobs done with Link-Belt cranes and other equipment. One interesting job is the grubbing out of some 52-year-old trees in Cuba. House organs such as these are valuable in suggesting new uses for handling equipment on the basis of showing how various organizations have applied their equipment.

New Booklet on Pavement Repairs—In support of the claim that the upkeep of paving is not as much of a dry-as-dust affair as is commonly supposed, we have for distribution an entertaining little book entitled "The Life, Adventures and Death of a Pest." To those of you who are concerned with the upkeep of highway or city paving, this book will bring an interesting message and at the same time furnish you and your friends with material over which you will probably get a good many laughs. If you will send your name and address we will see that you get your copy promptly.

Gasoline Rollers.—The Huber Manufacturing Company, Marion, Ohio, has issued a new catalog on Huber rollers, giving a lot of interesting information on their machines and what they can do. All important features are covered in detail. The Huber roller is made in 5-ton, 7-ton, 10-ton, and 12-ton sizes, designed for macadam work, for rolling subgrade, and for rolling sheet asphalt. A scarifier attachment, of course, is supplied.

Cold Patch.—Tarvia K-P, a useful cold patch material for any type of pavement, is described in a little booklet entitled "Helpful Hints for the Repair Gang Foreman," recently issued by The Barrett Company, 40 Rector St., New York City.

Motor Graders.—The Good Roads Machinery Co., Kennett Square, Pa., has issued a complete catalog of Good Roads Motor Graders, a series that has been designed for use with the various light tractors that have proven popular in the highway field. Structural details are described and each model is illustrated.

Rollers.—Good Roads Senior and Junior rollers are described in detail in a catalog on Good Roads Rollers recently issued by the Good Roads Machinery Company, Kennett Square, Pa. The larger roller is based on the McCormick-Deering tractor, while the Junior is based on the Fordson as a power unit. Both are very interesting machines.

Admixtures for Concrete.—Celite Products Co., Los Angeles, Calif., in their recently issued Bulletin No. 337, present a useful specification sheet for architects and engineers covering the use of Celite in concrete.

Steel Forms.—Blaw-Knox Company, Pittsburgh, Pa., have issued a new bulletin, No. 1024, covering their line of steel forms for curb, curb and gutter, and sidewalk construction. Many applications of these forms are shown and full information is included on how the forms are built and what they will do.

Industrial Notes

The Roller Bearing Co. of America, which has been engaged in Newark, N. J., since 1919, in the manufacture and sale of high grade roller bearing, has just concluded the purchase of the large plant of the Mercer Motor Car Co., in Trenton, N. J. They will install their present equipment in that plant and obtain a large amount of new equipment required to take care of their growing sales. The Mercer plant which the Roller Bearing Co. has acquired occupies 11½ acres and the buildings have 175,000 square feet of floor space. These buildings are of modern mill construction with one story, with daylight and saw-tooth roofs. Railroad sidings serve the plant on two sides, and the property is adjacent to the main line of the Pennsylvania Railway. This plant will be one of the best equipped and most modern manufacturing plants in the state. Joseph C. Trainer, wealthy Philadelphian, is president of the Roller Bearing Co. of America. Mr. Trainer is prominent in business and civic activities, and he is director in four Philadelphia banks. David H. Litter, of Newark and New York, associated with Mr. Trainer, is secretary. Emanuel P. Scheck, of the well known Newark law firm of Osborne, Cornish & Scheck, is the attorney for the company, and also a member of the firm. Allen H. Jones and John J. Berlise, of Belleville, are respectively vice-president and treasurer. They are the original founders of the Roller Bearing Co. of America, and are in direct charge of its operations. They started this business nine years ago in a small way in Roseville, and then moved to their Belleville factory. They developed the business to a point where it outgrew their Belleville shops, and then moved to 141 Frelinghuysen Ave., Newark, which location has been found far too small for their expanded requirements. Homer S. Trecartin, an efficiency and sales engineer of wide experience, is director of sales.

W. O. Washburn, on April 30, sold his partnership interest in the American Hoist & Derrick Co. to Mr. Frank J. Johnson, the senior partner and one of the founders of the business. The business will be continued as the American Hoist & Derrick Co. under the form of a corporation with the following officers: F. J. Johnson, president and treasurer; Howard S. Johnson, vice-president in charge of sales; Frederic Crosby, vice-president in charge of production. No announcement has been made by Mr. Washburn as to what his future business connection may be.

The New Jersey Tractor Co., Inc., of Garwood, N. J., announce their appointment as dealers and service representatives for the Caterpillar Tractor Co., serving the counties of Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union, and Warren, in the state of New Jersey. Complete stocks of equipment and parts and a competent service organization for caterpillar tractors will be maintained at their offices in the Bell Terminal, Garwood, N. J., Telephone, Westfield 1230.

The Kalman Steel Company has opened an office in Washington, D. C. (811 Barr building), which will act as a sub-agency to the Baltimore district office. Mr. Howard M. Lloyd will be in charge of the office and will act as sales engineer.

Mr. H. J. Loebl, for a number years in the service department of the Sterling Motor Truck Co., has been appointed assistant in the service department of the Waukesha Motor Co., Waukesha, Wisconsin. Mr. Loebl's wide experience and acquaintance in the outside field has made him many friends, and it is in line with the policy of his new organization to extend the friendly service which Mr. Loebl is so well prepared to promote.

Mr. W. C. Keifer, who has been connected with automotive service for a number of years with Buda and latterly with the Waukesha Motor Co., is in charge of the field service activities for the latter.

The Armstrong Mfg. Co., New York City, announce that on May 1 the management of the concern was taken over by another branch of the Armstrong family. Mr. Frederick S. Ashmun, secretary and treasurer, is a grandson of Mr. Frank Armstrong, who founded the business in1869. The president, Mr. B. I. Ashmun, is the father of Frederick S. Ashmun, secretary and treasurer, and has been continuously associated with the business since 1893. Mr. Ashmun is vice-president of the West Side Bank and president of the Home Building & Loan Association, both of Bridgeport, Conn. Mr. Leslie H. Taylor has been placed in charge of sales for the middle west. He has opened an office for the Armstrong Company at 9 S. Clinton St., Chicago. Mr. Taylor is well known to the trade; he was sales manager for the William Pipe Threading Machine Co. of Erie, Pa., and was to a large extent responsible for the popularity of the "Willie" Williams Pipe Threader. On May 1, the New York sales and general export offices of the Armstrong Mfg. Co. moved from 181 Lafayette St., New York City, to their present commodious quarters at 27 Cleveland Pl. (corner Spring and Lafayette Sts.). The new offices are much larger and are beautifully situated on the eighth floor of the building, and the new location is accessible to any part of the metropolitan district. The friends of the Armstrong Mfg. Co. will receive a hearty welcome when they call at the new address. The Self Propelling Nozzle Company, manufacturers of hydraulically operated sewer maintenance equipment, have joined forces with the Armstrong Mfg. Co. in their new quarters. Mr. H. S. Ashmun, president of the Self Propelling Nozzle Company, is a brother of Mr. B. I. Ashmun of the Armstrong Mfg. Co.

The Servicised Products Corporation, Chicago, have doubled their plant capacity over 1927 and have acquired property at New Orleans for the manufacture and distribution of expansion joint at that point. This corporation was successful in securing the contract with Wayne County, Michigan, for their road work for 1928, furnishing 25 carloads of expansion joint. They are now manufacturing expansion joint with felt sides, a matted felt fibre core, in addition to their regular style "B" Joint. Servicised is also introducing Cork Seal Joint which comprises 75 per cent asphalt, 18 per cent ground cork and 7 per cent fibre. This is primarily for buildings and where high resiliency is required in an expansion joint. Servicised is also introducing their Gray Crown Joint for municipalities in a commercial way and have so increased their facilities that they can make prompt delivery to every part of the country. Among other products, Servicised is producing bridge flooring, railroad crossing planks, industrial flooring and other building products.

Walter F. Faber, former General Manager of the Fort Pitt Construction Company, Pittsburgh, has been appointed Field Engineer of the Western District of the Eastern Paving Brick Manufacturers Association with headquarters at Pittsburgh. Mr. Faber is an engineer of considerable experience, and since 1920 has been engaged in the construction of highways as General Manager of the Fort Pitt Construction Company.